Facial Aesthetics In Adolescents

Rosemie Kiekens

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About the cover
The paintings on the front and the back cover are made by the author and show her children at childhood and as adults.
This thesis is about what is concealed for the beholder: faces at adolescence.

Facial Aesthetics In Adolescents

Een wetenschappelijke proeve op het gebied van de Medische Wetenschappen

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The study presented in this thesis was conducted at the Department of Orthodontics and Oral Biology (Head: Prof. A.M. Kuijpers-Jagtman), College of Dental Science, of the Radboud University Nijmegen Medical Centre, Nijmegen, The Netherlands.
The College of Dental Science participates in the Netherlands Institute for Dental Sciences (IOT).

Aan mijn ouders en mijn kinderen

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Chapter 1

General introduction

1.1 Introduction

Beauty and especially facial beauty has attracted considerable attention in recent years. Being beautiful is an advantage in a variety of important real-live situations, and is found to be as important for males as for females and for children as for adults. Attractive children and adults are judged and treated more positively than unattractive children and adults, even by those who know them.[1] Attractive people are assumed to be more sociable, happier and more successful than unattractive people.[2] Attractive students are judged by their teachers to be more friendly, more popular and more intelligent than unattractive students and they receive higher scores on standardized achievement tests at school than unattractive children.[3,4] Attractive suspects get lower punishments than unattractive ones.[5] Being beautiful is an advantage for those who apply for a job.[6] In other words "what is beautiful is good".[2] Although beauty might be related to superficiality ("beautiful blonds are stupid"), and although some "beauty is beastly"-effect has been noticed for females seeking a job that traditionally requires masculine characteristics,[7] nobody prefers to be ugly.[8]

Apart from being judged and treated better, attractive children and adults also behave differently. Compared with unattractive children, attractive children display greater intelligence and performance competence. Compared with unattractive adults, attractive adults have more dating and sexual experience, and a better physical health. Attractive adults are also more extravert, have a higher self-confidence and self-esteem than unattractive adults.[1] In their meta-analytic review Langlois et al.[1] conclude that people do judge and treat attractive people more positively than unattractive ones and attractive people do behave differently than unattractive ones. In other words: Beauty is more than just skin-deep. Beauty is a powerful and advantageous quality.

There is a hierarchy among the components of the total body in judging attractiveness, with the face being the most important component.[9] According to Synnott,[10] the face is the principal locus of both beauty and character The mouth and the teeth seem to be clues for assessing facial attractiveness.[11-13]

In the light of the above-mentioned, it is not surprising that aesthetic improvement is the most frequently reported reason for seeking orthodontic treatment.[14-16] Patients and their parents believe that they will be more attractive with straight teeth and an attractive smile.[17] They rate pleasant dental aesthetics as an important factor for psychosocial well-being.[18-20]

1.2 Evaluation of facial aesthetics

Facial beauty is a subjective entity, and different people may have different ideas about what is beautiful and what is not. In 1878 Margaret Hungerford wrote in her novel 'Molly Bawn': "Beauty is in the eye of the beholder".[21] However, a recent meta-analysis has shown that both within and across cultures, people agree about who is and who is not attractive and that the eyes of the beholders come to similar judgments. This means that the concept of facial aesthetics as an entirely subjective entity might not be correct.[1]

Within the evaluation of facial aesthetics, orthodontists are focused on dental aesthetics. This is reflected in the indices accepted within their profession, such as the Aesthetic Component of the Index of Orthodontic Treatment Need (AC/IOTN),[22,23] the Dental Aesthetic Index (DAI),[24,25] the Index of Complexity, Outcome, and Need (ICON),[26,27] and the PAR index.[28] These indices all deal with dental aesthetics as an important parameter in judging treatment need and treatment outcome. However, none of these indices deal with facial aesthetics. Therefore, orthodontists may have a different perception of facial aesthetics than their patients and/or their parents. Besides, an orthodontic treatment that is considered to be successful does not always improve facial aesthetics,[29-31] and therefore such a treatment might be less successful in the eyes of the patient than in the eyes of the orthodontist.

Since dental and facial aesthetics are two different parameters, a measuring system for treatment need and outcome should include dental as well as facial aesthetic scales.[32,33] Reliable measures of facial aesthetics are essential in meaningful research on that subject. Since long,

investigations on the objective evaluation of facial aesthetics have been performed, and different methods have been used in order to evaluate facial aesthetics. Three components should be considered in the evaluation of facial aesthetics: the way the subjects are presented, the characteristics of the judges, and the measuring instruments.

1.2.1 Presentation of the subjects

The use of lateral cephalograms, silhouettes of profiles or photographs taken in profile, en face or three quarter (smiling) orientation as stimuli, has been reported in literature. In more recent research, static 3D images and dynamic video registration have also been used.[34-36]

A close relationship was found between judgments of facial aesthetics on live stimuli and single colour photographs.[37] This means that photographs can be used for the evaluation of facial aesthetics. A simultaneous presentation of frontal and profile views was found to be advantageous over a single view.[32] Powell and Rayson[38] advocated the addition of a three-quarter smiling view for a more complete analysis of the face. The fact that sets of photographs are usually available in orthodontic practice facilitates their use.

1.2.2 Characteristics of the judges (panel members)

Panel assessments to evaluate facial aesthetics before and after orthodontic treatment have been widely used. In the development of a measuring instrument it is important to know if patients and/or their parents evaluate facial aesthetics the same way as orthodontists. Research in this field has led to conflicting results. Although high correlations have been reported between professionals and laymen,[39,40] some investigators have shown that professionals are more critical than laymen[41] while others found the opposite.[32,33,42]

Other factors related to individual characteristics of the panel members such as age, gender and/or regional background might also influence their ratings. In the comparison of judgments of panel members, differences in panel composition concerning age and gender can lead to conflicting results.[40]

Panel size is another issue that should be taken into consideration. The literature shows a wide range in panel sizes. Howells and Shaw (1985) found that for the evaluation of facial aesthetics, a panel of two persons can give acceptable reliable results, but for improvement of the reliability, they advocated an increase in panel size. However, the optimal size of such a panel has never been established.

1.2.3 Measuring instruments

Visual analogue scales (VAS) have been often used as a measurement technique to evaluate facial aesthetics.[32,37,42-46] With such a scale, photographs of individuals are to be judged by panel members on a line from 0 (very unattractive) to 100 (very attractive). Most authors have used a VAS without reference photographs.[32,37,42] More recently the use of reference photographs, one for boys and one for girls, has been advocated.[39,59]

Likert scales i.e. number scales (e.g. 5, 6, 7, 10 or 11 point scales, from very unattractive to very attractive or vice versa) also have been used in the evaluation of dentofacial and facial aesthetics.[33,40,41,47-50]

For the comparison of facial aesthetics before and after orthodontic or orthognatic treatment both scale types have been used, by evaluating separately pre- and post-treatment photographs.[32,40-42,49,50] Another approach is to compare the pre-/post-treatment pictures in one session.[51,52] By this procedure the improvement has been estimated in percentages on a VAS (0% to 100% improvement)[51] or on a VAS extending from “extreme worsening” to “extreme improvement”.[52] These methods are hindered by the fact that thinking and rating in percentages is a complicated procedure. Furthermore, the interpretation of anchor points such as “extreme worsening” or “extreme improvement” is not uniform. The use of a simple 5-point scale, with scores varying from -2 = markedly worsened, to +2 = markedly improved, for the evaluation of facial aesthetics change after treatment (in analogy with the determinations in the PAR Index), probably would be easier and more practical in use. Such an approach, however, has never been reported.

1.3 Facial aesthetics and its relation to facial features

During the last decades orthodontists have focused their treatment plans more and more on improvement of facial aesthetics. Objective parameters (Overjet, ANB angle, Sn-GoGn angle) and Angle Class measured on dental casts and radiographs, and dental aesthetics measured on dental casts and dental photographs (AC/IOTN)[22,23] have been proposed in the literature. Golden ratios[53-56] and so-called "ideal" proportions and angles, based on beautiful and idealized faces, on authors' preferences, or on average faces,[34,57-72] measured on photographs or by anthropometry, also have been suggested. Although it is not always possible to change non-ideal facial dimensions, ratios and angles by orthodontic treatment, orthodontists rely on them in making their treatment plans. However, little evidence is found from the literature for the relation between these objective parameters, "golden" and "ideal" ratios and angles with facial aesthetics in adolescents.

1.4 Objectives of this thesis

Most orthodontic treatments in Europe are performed during adolescence and also for adolescents aesthetic improvement is the most frequently reported reason for seeking orthodontic treatment. Little research has been performed on the evaluation of facial aesthetics in adolescence. Therefore, it was the overall aim of this study to investigate facial aesthetics in adolescents and the effect of orthodontic treatment hereupon.

The specific aims of this investigation are:

- to develop a simple and valid measuring system for facial aesthetics in young Caucasian boys and girls and to test its reproducibility and validity
- to evaluate the influence of, and the possible interaction between professional background, age, gender, and geographical region of panel members on their evaluation of facial aesthetics in adolescents

and on facial aesthetic change after orthodontic treatment in adolescents
- to find evidence for optimal panel size for epidemiological investigations on facial aesthetics
- to investigate if Angle Class and gender of the patients have an influence on their facial attractiveness before and after treatment as evaluated by professionals and laymen
- to determine which objective measures (such as overjet, ANB angle, SN-GoGn angle and AC/IOTN) used in daily orthodontic practice are related to facial aesthetics as perceived by laymen
- to determine if golden ratios and norms reflecting symmetry or average and "ideal" proportions and angles, as proposed in the literature, are dealing with facial attractiveness in adolescents as perceived by laymen

1.5 Overview of the thesis

Chapter 1 introduces the topic of facial aesthetics in general, and the aims of this study for the investigation of facial aesthetics in adolescents in specific.

In *chapter 2* a measuring system for facial aesthetics is presented with its reproducibility and validity.

Chapter 3 describes the influence of panel composition on the aesthetic evaluation of adolescent faces and the "optimal" panel size for judgment on a VAS scale.

Chapter 4 describes the influence of panel composition on the change of facial aesthetics after orthodontic treatment and the "optimal" panel size for judgment on a 5-point scale.

Chapter 5 describes the study of the contribution of objective parameters representing anterior-posterior and vertical characteristics, and dental aesthetics (or their combination) in the assessment of facial aesthetics.

Chapter 6 reports on "golden proportions" contributing to facial aesthetics in adolescents, as indicated in the literature.

Chapter 7 reports on the so called “ideal” ratios and “ideal” angles, as proposed in the literature and their relationship with facial aesthetics in adolescents.

In the general discussion, *chapter 8*, the most noteworthy findings of the previous chapters are discussed and some suggestions for future research are given.

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Chapter 2

A measuring system for facial aesthetics in Caucasian adolescents: reproducibility and validity

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Summary

A new measuring system to judge facial aesthetics in young Caucasians is presented. The system uses sets of three photographs (one frontal, one three-quarter smiling and one lateral) as a stimulus. Scores are performed on a visual analogue scale (VAS) with separate sets of reference photographs for girls and boys. The choice of the reference photographs was based on a panel evaluation of facial aesthetics of 40 boys and 40 girls from the archive of the orthodontic department. Reproducibility of the new measuring system was tested on a series of photographic sets (one frontal, one three-quarter smiling and one lateral view) of 64 patients, using a panel of 78 adult laymen and 89 professionals. The panel members assessed these sets of photographs on a VAS, in relation to the reference sets.

The system was shown to be reproducible. Although the intra-observer reproducibility was low, the reliability coefficient was excellent (Cronbach's alpha ≥ 0.98). Validity was tested by comparing the scores on the new scale with those of the three-quarter smiling photographic views on an earlier published scale. The correlation between the ratings on the new measuring system and the earlier published scale was 0.82 for laymen and 0.77 for professionals. The new system is simple and flexible in its use, and reproducible and valid for assessing facial aesthetics in young Caucasians. The system can be used in further investigations on the evaluation of facial aesthetics.

2.1 Introduction

Facial aesthetics are an important social concern in current society. Over 70 percent of parents believe that their child will become more attractive, better liked, and more successful in its future occupational life after orthodontic treatment.[1] Children, young adults, and parents rate pleasant aesthetics as an important factor for psychosocial well-being.[2-4] Aesthetic improvement is the most frequently reported subjective reason for seeking orthodontic treatment.[5-7] This means that an assessment of dentofacial appearance should be included in the evaluation of orthodontic treatment need and treatment outcome.[8]

Orthodontists often focus on dental aesthetics. This is reflected in the indices or measuring systems, accepted within their profession, such as the Index of Orthodontic Treatment Need (IOTN),[9,10] the Index of Complexity, Outcome, and Need (ICON),[11] the Social Acceptability Scale of Occlusal Conditions (SASOC),[12] the Dental-Facial Attractiveness scale (DFA),[8] and the Dental Aesthetic Index (DAI).[13] These indices and scales all deal with dental malocclusions but not with overall facial aesthetics. However, an orthodontic treatment that is successful in the eyes of the professional does not always improve facial aesthetics,[14,15] or facial balance,[16] and therefore might be considered to be less satisfying in the eyes of the patient. Since dental and facial aesthetics are two different parameters, a scoring system for orthodontic treatment need and treatment outcome should include dental as well as facial aesthetic scales.[15,17] Such a ‘facial aesthetics’ scoring system preferably has to be simple, applicable in clinical practice, and should lead to quantitative data.[18,19]

Three components should be considered in developing such a scoring system: the way the subjects are presented, the characteristics of the judges, and the measurement technique.

The use of lateral cephalograms, silhouettes of profiles, or photographs taken in profile, frontal or three-quarter (smiling) orientation as stimuli, has been reported in the literature. All methods have their advantages and disadvantages. Lateral cephalograms and silhouettes have the advantage of reducing or eliminating the influence of confounding

variables,[20] but they do not represent the whole face and the actual smile cannot be evaluated,[21] a drawback that these stimuli have in common with lateral photographs. Furthermore, other factors may surpass the influence of the profile outline on facial aesthetics.[22]

Frontal photographs generally are rated more attractive than profile views,[23] and simultaneous presentation of frontal and profile views probably would be advantageous.[17] Three-quarter (smiling) colour photographs have also been advocated,[24,25] and probably the most complete visualization can be achieved by the combined use of frontal, lateral, and three-quarter (smiling) photographs.

In almost all cases, panel assessments have been used to evaluate facial aesthetics. Since the perception of facial aesthetics might be related to regional and/or professional background, age, or gender of the judges, much attention has been paid to the comparison of panels with different composition. Research in this field, however, has led to conflicting results. For example, Peerlings *et al*.[25] found no effect of panel composition, while Spyropoulos and Halazonetis[22] reported professionals to be less critical and Kerr and O'Donnell[23] found professionals to be more critical than laymen.

Visual analogue scales (VAS) are most often used as a measuring instrument for dental, dentofacial, or facial aesthetics. Most authors have used a VAS without reference photographs,[17,24,26] but more recently the use of reference photographs has been advocated.[25,27] Reference photographs can help the panel members to use the scale more uniformly, but preferentially their number should be minimized for the sake of simplicity of the scale. Therefore, in this study only one reference set in the mid-point of the scale was chosen.

The aim of this study was to develop a simple and valid measuring system for facial aesthetics in young Caucasian boys and girls, and to test its reproducibility and validity. Reproducibility includes the calculation of errors and reliability coefficients.

2.2 Materials and methods

The first step was the selection of the reference sets, one for the boys and one for the girls. In a second step the system with the reference sets was evaluated.

2.2.1 Selection of reference photographs

The 1990-2000 files of the Department of Orthodontics and Oral Biology, Radboud University Nijmegen Medical Centre, The Netherlands, were searched for sets of pre-treatment slides containing standardized frontal, three-quarter smiling and profile photographs of Caucasian children, aged 10 to 16 years, not wearing glasses, and without dental or facial trauma or known congenital defects. These inclusion criteria were met by 366 males and 398 females. From these, 40 males and 40 females were randomly selected to serve as a baseline. From each individual a set of photographs was prepared showing the three views simultaneously. The sets were placed in a random order to create a slide show to be projected on a wall screen. A panel of 49 dental students (22 males and 27 females), aged 18 to 26 years was instructed to rate each face on a VAS from 0 to 100 (i.e. very unattractive to very attractive). Each set of photographs was shown for 15 seconds. No additional information about the faces was given.

Means and standard deviations (SDs) of the ratings by the panel were calculated for each set of photographs. These mean VAS values ranged from 19 to 71. The median score was 50.1. The SD of the ratings for the individual faces varied from 8.6 to 19.2. One male and one female set of photographs with an average aesthetic score close to the median value and a SD close to 8.6 were then selected to serve as reference sets for the measuring system. The male reference set (age = 14.3 years) had a VAS score of 53.1 (SD = 10.2), the female set (age = 11.7 years) had a VAS score of 56.1 (SD = 9.9), (Figure 2.1 a,b).

2.2.2 The measuring system, its reproducibility and validity

The proposed measuring system for the judgment of facial aesthetics consisted of a set of standardized photographs (frontal, lateral, and three-

quarter smiling) of the experimental subjects together with a set of reference photographs of the same gender. Facial aesthetics of the experimental subjects was scored on a VAS. In order to determine the reproducibility and validity of such a scoring system, it was tested on a series of 64 sets of photographs of orthodontic (pre-treatment) patients, and the judgment was performed by a professional and a lay panel. This resulted in over 8000 individual scores on facial aesthetics. The 64 patients used in the experimental group, were randomly selected after stratification in order to have approximately eight boys and eight girls for each of the four Angle Classes.

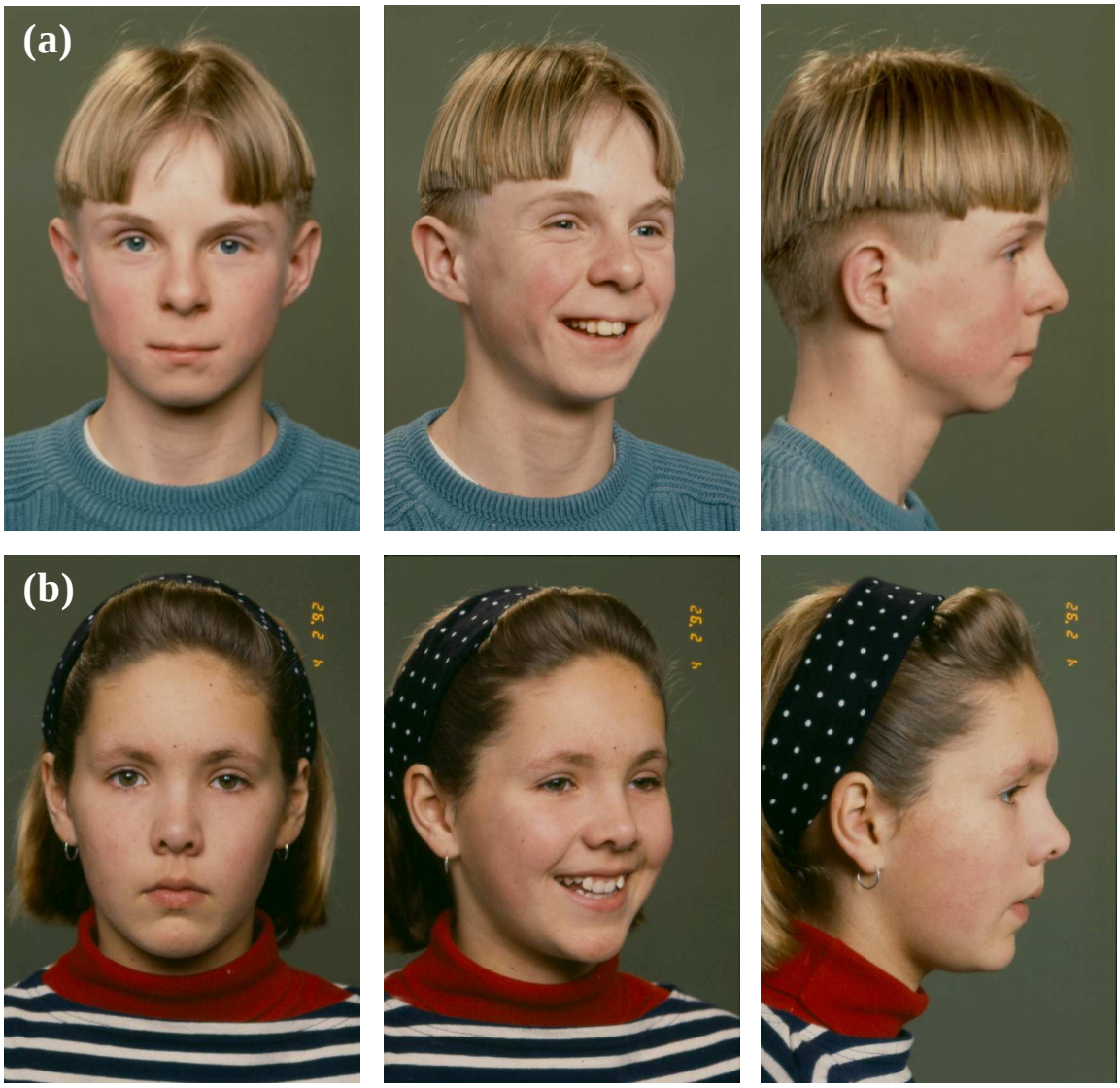

Figure 2.1 *Reference photographs for (a) boys and (b) girls. Indicated score on a visual analogue scale was 53.1 and 56.1, respectively.*

The determination of the Angle Classes was as follows:

Class 1: neutro-occlusion and neutro-relationship of the jaws.
Class II division 1: disto-occlusion and disto-relationship of the jaws with proclined upper incisors.
Class II division 2: disto-occlusion and disto-relationship of the jaws with retroclined upper incisors.
Class III: mesio-occlusion and mesio-relationship of the jaws.

The inclusion criteria were the same as described in the previous section. Existing photographs from each individual were combined into a set of three, showing a frontal, a lateral, and a three-quarter smiling view simultaneously. The sets were randomly placed in a slide show and projected on a wall screen, showing every female face in relation to the female reference set, and every male face in relation to the male reference set. A panel of 78 adult laymen and a panel of 89 professionals (85 orthodontists and 4 postgraduates) were constructed. The composition of the panels with respect to age and gender is given in Table 2.1. The members of both panels all had a relatively high socio-economic status.

Table 2.1 *Composition of the panels.*

	Laymen (*n* = 78)	**Professionals (*n* = 89)**
Male/Female	38/40	38/51
Mean age ± SD (years)	51 ± 10.3	42 ± 8.8
Median age (years)	50	41
Age range (years)	28-76	25-65

Each set of photographs of one individual, together with the reference set, was shown for 15 seconds and the panel members were asked to assess facial aesthetics in relation to the reference set of which the VAS score was indicated, on a VAS from 0 to 100. In order to evaluate intra-individual reproducibility of the measuring system, six duplicate sets of the individuals were added to the series.

Since no criterion or gold standard exists to define facial aesthetics,

other investigations had to be used to validate the measuring system. According to Streiner and Norman[28] concurrent validity is 'where a new scale is correlated with the criterion measure, both of which are given at the same time'. The only photographic scales in assessing facial aesthetics in healthy Caucasians found in current literature were the Peerlings scales.[25] This system uses separate scales for two age groups and for males and females, each with five three-quarter smiling reference photographs. In order to estimate the validity of the measuring system, the photographic three-quarter smiling views of the individuals from 11 to 13 years and from 14 to 16 years (n = 44) that were included in the sample, were also evaluated using the Peerlings scales. The ratings were undertaken by four orthodontists and four postgraduate students, familiar with the Peerlings scales. The ratings on the Peerlings scales given by the small professional panel were compared with the VAS values given by the laymen and the professionals using the new measuring system.

2.2.3 Statistics

Means and standard deviations (SDs) of the ratings for each set of photographs were calculated per panel. The ratings of two laymen were excluded because of missing data. In this situation of sufficient normally distributed ratings, a two-way ANOVA was performed to evaluate the effect of gender and Angle classification on the ratings. Tukey's test for multiple comparisons was applied in case of significant effects.

In the statistical evaluation of the reproducibility of the measuring system, the random error of the duplicated photographs was calculated according to Dahlberg.[29] The intra-observer consistency was calculated by Pearson's correlation coefficient and intraclass correlation coefficient (ICC). The reliability coefficient for the final score was calculated by Cronbach's alpha. The difference in judgment between laymen and professionals was studied by a paired t-test.

The reproducibility of the measuring system was also statistically evaluated by Pearson's correlation between the ratings of the laymen and those of the professionals.

Concurrent validity was determined by calculating Pearson's correlation coefficient between the ratings on the VAS given by the two

panels, and the scores on the Peerlings scales given by four orthodontists and four postgraduates.

2.3 Results

2.3.1 Reproducibility of the measuring system

The random error of the measurement score of the duplicate photographs varied over the panel members, from 2 to 17 VAS points in the laymen panel and from 0 to 35 VAS points in the professional panel. The median individual random error was 6.8 VAS points (P25 = 4.7; P75 = 10.5) for the laymen and 10.6 VAS points (P25 = 6.4; P75 = 19.8) for the professionals. The intra-observer consistency was expressed as the Pearson's correlation coefficient between the first and the second rating of the duplicate photographs and was 0.68 (P25 = 0.44; P75 = 0.81) for the laymen and 0.65 (P25 = 0.48; P75 = 0.84) for the professionals. The ICC was 0.56 (P25 = 0.25; P75 = 0.73) for the laymen and 0.53 (P25 = 0.32; P75 = 0.73) for the professionals. The reliability coefficient of the final overall score was excellent: Cronbach's alpha was 0.98 for the laymen and 0.99 for the professionals. The professionals scored four VAS points lower compared with the laymen (95% CI = 2.6 – 5.2; P = 0.000). Pearson's correlation coefficient between the mean VAS scores of the laymen and those of the professionals was 0.92.

2.3.2 Validity of the measuring system

Pearson's correlation between the ratings given on the Peerlings scales by the small panel and the mean VAS values given by the laymen was r = 0.82. Pearson correlation with the mean values given by the professionals was r = 0.77.

The outcome measures consisted of over 8000 individual assessments of facial aesthetics. VAS means and SDs of the different panels for the two stratification factors, Angle Class and gender were calculated (Table 2.2). There was no significant difference in the aesthetic scores for boys and girls (ANOVA, both panels $P > 0.25$). A significant effect of Angle Class was seen in the ratings by the

professionals (P = 0.02). Although the same trends were found, these findings were not significant in the laymen ratings (P = 0.08). Tukey's test revealed that Angle Class II division 2 patients were considered significantly more attractive than Angle Class III patients ($P < 0.05$ both for laymen and orthodontists). There was no significant interaction between gender and Angle Classification (interaction test, $P > 0.30$).

Table 2.2 *Mean ± standard deviation (SD) of the aesthetic scores on the visual analogue scale given by laymen and professionals, according to gender and Angle Class of the subjects.*

Angle Class	**Boys (*n* = 32)**				**Girls (*n* = 32)**			
	Laymen		Professonials		Laymen		Professionals	
	n	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD
Class I	8	52.6 ± 7.8	8	45.2 ± 11.2	7	56.8 ± 6.1	7	56.3 ± 11.7
Class II division 1	9	55.8 ± 11.3	9	49.2 ± 11.9	9	51.9 ± 11.5	9	47.3 ± 15.6
Class II division 2	8	60.4 ± 4.6	8	58.3 ± 5.6	8	55.2 ± 4.3	8	56.2 ± 7.1
Class III	7	51.7 ± 9.4	7	44.3 ± 9.5	8	47.2 ± 11.6	8	43.9 ± 14.5
Total	32	55.3 ± 8.9	32	49.4 ± 10.9	32	52.6 ± 9.5	32	50.6 ± 13.4

2.4 Discussion

The aim of the present study was to develop a simple and valid measuring system for facial aesthetics. It was decided to investigate whether this goal could be met, using sets of three colour photographic views of one individual (one frontal, one three-quarter smiling, and one profile) as a stimulus and a similar set as reference photographs. Such sets of photographs do not express a person's whole facial attractiveness since dynamic characteristics are not taken into account. Howells and Shaw[24] however, have shown that a close relationship exists between judgments of facial aesthetics on live stimuli and single colour photographs. Simultaneous presentation of multiple views of an individual might even improve this relationship.[17] An important advantage of the use of these

sets of facial photographs is that they are usually available in orthodontic offices.

The measuring system used two reference sets of photographs, one for boys and one for girls. These reference sets were chosen since their aesthetic scores were closest to the mean value found for a series of 40 randomly chosen individuals per gender. The use of these reference sets of photographs resulted in a median intra-observer consistency of 0.68 for the laymen and 0.65 for the professionals, and an ICC of 0.56 for the laymen and 0.53 for the professionals. The value of Pearson's correlation coefficient, and especially the ICC, was low but acceptable. Low correlations are often an issue when measuring subjective commodities such as facial appearance, and therefore a large number of panel members were asked for their opinion. Pearson's correlation between the VAS scores given by the laymen and those given by the professionals was 0.92, meaning that a good agreement was found between both panels. The concurrent validity of this scale with the Peerlings scale was 0.82 for the laymen and 0.77 for the professionals. This indicates that with the reference sets of photographs as used in the present investigation, an adequate measurement of facial aesthetics can be achieved. The measuring system is reproducible and valid and can be used, for example, for inter-centre audit studies.

A point of discussion in the present study might be the composition of the panels. All laymen had a relatively high socio-economic status. The choice of panel was such because orthodontic treatment demand in higher socio-economic groups is greater than in lower socio-economic groups, whereas the objective treatment need is independent of socio-economic status.[30] These laymen may be representative for that part of the general public most often dealing with orthodontic treatment demand. Although the professionals gave lower scores (i.e. were more critical) than the laymen, the correlation coefficient between both panels was very high (0.92). This is in agreement with Lundström *et al.*[31] and Kerr and O'Donnell.[23] However, it is in contrast with Lines *et al.*[32] and Peerlings *et al.*[25] who did not find any difference, and with Tedesco *et al.*,[8] Phillips *et al.*,[17,26] Giddon *et al.*[33] and Spyropoulos and Halazonetis,[22] who found that dental professionals were less critical than laymen.

In the present study Angle Class II division 2 patients were considered to be more attractive than Class III patients. In most investigations Class I profile patients were considered to be the most attractive.[23,34-39] Michiels and Sather[35] found Class II profile patients the least attractive, but they also stated that marked cheek bones and lower jaw borders were more often mentioned for the most attractive than for the least attractive patients. This finding might be related to the fact that Class II division 2 profile patients have pronounced cheekbones and lower jaw borders. However, although the scores for the Class II division 2 patients were the highest, it cannot be concluded that they are significantly the most attractive of all patients. We only can state that they are significantly more attractive than Class III patients.

The measuring system will be used in future studies, with a panel of laymen only, since the present study has shown that a high correlation exists between the ratings of professionals and laymen. Moreover, as stated by Bowman and Johnston[40] the opinion of the end-users of orthodontic services may have the most value in determining the appropriateness of aesthetic results. Therefore, the opinion of laymen on facial aesthetics is valued more highly than that of professionals.

2.5 Conclusions

This newly developed measuring system for facial aesthetics in young Caucasian boys and girls, in which two separate sets of reference photographs, one for boys and one for girls were used, showing the frontal, three-quarter smiling, and profile face simultaneously, has been shown to be reproducible and valid, and therefore can be used in future research, and especially in inter-centre audit studies.

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Chapter 3

Influence of panel composition on aesthetic evaluation of adolescent faces

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Summary

The objective of this study was to evaluate the influence of professional background, age, gender, and geographical region of panel members on their evaluation of the facial aesthetics of adolescents, and to assess the optimal panel size for epidemiological studies on facial aesthetics.

A panel of 76 adult laymen from two different regions (Belgium and The Netherlands) and a panel of 89 orthodontists from the same two regions, evaluated photographic sets (one frontal, one three-quarter smiling, and one lateral view) of 64 adolescents (32 boys, 32 girls) on a visual analogue scale (VAS) in relation to a reference set of photographs. The effects of the characteristics of the panel members on the VAS scores for boys and girls separately, as well as their interactions, were evaluated by multilevel models. The adolescents entered the model as a random effect and four characteristics of the panel members were included in the model as fixed effects.

The multilevel model with main effects and first-order interactions revealed that laymen rated adolescents as more attractive than orthodontists. This finding was significant for all laymen, except for older males, and Belgian laymen, when rating girls. Older panel members rated boys significantly more attractive than younger panel members. Males rated adolescents more attractive than females. The latter was significant for all male subgroups, except for the lay male subgroup. There were regional differences.

Based on the intraclass correlation coefficient, a panel of seven randomly selected laymen and/or orthodontists is sufficient to obtain reliable results in the aesthetic evaluation of adolescent faces, using photographs and a VAS.

3.1 Introduction

In investigations of facial aesthetics, judgments of panels have often been compared, but conflicting results have been reported. Differences in study design may, to a large extent, be responsible for these conflicting results. In addition, factors related to the individual characteristics of the panel members such as professional background, age, gender, and geographical region may also influence the ratings. Although high correlations have been reported between professionals and laymen,[1-3] some investigations have shown that professionals are more critical than laymen,[3,4] while other studies found the opposite.[2,5-8] Differences in panel composition concerning age and gender can be confounders in this respect.[2]

The age of panel members was not found to be influential on their ratings of facial aesthetics.[9,10] The influence of gender of panel members on their ratings of facial aesthetics is not clear. Some studies indicated that the gender of panel members was not decisive for their ratings.[10,11] Other studies, however, suggest that females are less critical than males.[12] Cross and Cross[9] found that female laymen rated female faces as more attractive than male laymen, while female and male laymen rated male faces the same.

Limited research has been performed on the effect of the geographical region of panel members on the appreciation of facial aesthetics. Udry[13] reported on different preferences of feminine beauty in Britain and the United States; it appears that no publications are available on regional differences of panel members, assessing facial aesthetics in adolescents. Such regional differences, however, may be of interest for orthodontists moving to another region. They can benefit from this knowledge in their discussions on treatment expectations.

Panel size is another issue that should be taken into consideration. The literature shows a wide range in size.[3,6,7] Howells and Shaw[10] stated that for evaluation of facial aesthetics, a panel of two persons can give acceptable reliability, but for improvement, they advocated a further increase in panel size. However, the optimal size of such a panel has never been established.

The aim of this study was twofold: to evaluate the influence of, and the possible interactions between, professional background, age, gender, and geographical region of panel members on their ratings of facial aesthetics in adolescents, and to find indications for optimal panel size for epidemiological investigations of facial aesthetics.

3.2 Materials and methods

The 1990-2000 files of the Department of Orthodontics and Oral Biology of the Radboud University Nijmegen Medical Centre, The Netherlands, were searched for pre-treatment sets of three standardized photographs (one frontal, one three-quarter smiling, and one lateral) of healthy Caucasian adolescents. The inclusion criteria were: age between 10 and 16 years, not wearing glasses, and without dental or facial trauma or known congenital defects. From this group, 64 subjects were selected, using randomized stratification for Angle Class and gender. Angle Classifications were defined as follows: Angle Class I: neutro-occlusion and neutro-relationship of the jaws; Class II division 1: disto-occlusion and disto-relationship of the jaws, with proclined upper incisors; Class II division 2: disto-occlusion and disto-relationship of the jaws, with retroclined upper incisors; and Class III: mesio-occlusion and mesio-relationship of the jaws. This stratification was carried out to have approximately eight boys and eight girls for each of the four Angle Classes, in order to have a wide range of dental/skeletal variation.

A panel of 78 laymen, with a relatively high socio-economic status, from Flanders (the northern, Dutch-speaking part of Belgium) and The Netherlands, and a panel of 89 orthodontists (85 orthodontists and four postgraduates) from the same geographical regions evaluated the photographic sets. Distribution of geographical region, gender, and age for both panels is shown in Table 3.1. Ratings of facial aesthetics were performed on a visual analogue scale (VAS) in relation to reference sets of photographs, one for boys and one for girls, on which the VAS scores were indicated. Each set of photographs of one individual, together with the appropriate reference set, was shown for 15 seconds.

The panel members were asked to assess facial aesthetics of the individuals on a VAS from 0 (very unattractive) to 100 (very attractive). This method has been shown to yield reproducible and valid results.[3]

Table 3.1 *Distribution of geographical region, gender (m=male, f=female), and age (years) of laymen and orthodontists in the panels.*

Panel members	***n***	**Age**		
		Mean ± SD	Median	Range
Laymen				
Dutch	42 (26 m, 16 f)	53.2 ± 9.5	52	30-74
Belgian	36 (12 m, 24 f)	48.3 ± 10.7	47	28-76
Orthodontists				
Dutch	47 (29 m, 18 f)	46.5 ± 8.5	45	31-65
Belgian	42 (9 m, 33 f)	37.3 ± 6.4	38	25-53

SD, standard deviation

3.2.1 Statistics

Statistical analysis was performed on the ratings of a final panel of 76 laymen and 89 orthodontists. The ratings of two laymen were not taken into account because of missing data.

Means and standard deviations (SDs) of the ratings for each set of photographs were calculated for each panel, age, gender, and geographical region. The fixed effect for age was dichotomized at 46 years of age, which was the median age of the panel members, with 46 years and older = old and under 46 years = young.

The influence of professional (orthodontic) background, age, gender, and geographical region on the VAS scores for the boys and girls separately and their possible interactions were tested within the framework of multilevel models. Second-order and higher order interactions are difficult to interpret; therefore, only the model with the four main effects and first-order interactions were presented. Analyses were performed with the procedure ‘Proc Mixed’ in the statistical package SAS 8.0. (SAS® Software, SAS Institute Inc., Cary, North Carolina, USA).

The subjects were entered as a random effect in the analysis. Variance of the random effects, *V*b, is the between-subjects variance and reflects the variability of the VAS score between subjects. The within-subject variance, *V*w, reflects the variability of the panel members over the same subject. The intraclass correlation coefficient (ICC) is then given by *V*b/[*V*b + *V*w], which can be interpreted as the mean correlation of randomly selected pairs of single panel members. The ICC is 1 when all panel members agree perfectly on all subjects. When the within-subject variance is large (raters substantially disagree on the same subject) compared with the between-subjects variance, the ICC is close to 0. The VAS can be considered to be a reliable measure if the ICC is above 0.80. When the VAS panel score is based on the average VAS scores of *N* randomly selected raters, the ICC for pairs of panels is ICC(*N*) = *N* x ICC(1)/[1 + (*N* – 1) x ICC(1)].

The optimal panel size was found by choosing the smallest value of *N* where ICC(*N*) was substantial above 0.80 for girls as well as for boys.

3.3 Results

VAS means and SD of the aesthetic scores for boys, girls, and boys and girls taken together, for each given panel, age, gender, and geographical region, were calculated and are shown in Table 3.2.

The differences in VAS score are presented in Table 3.3 for professional background within subgroups, young, old, males, females, Belgian, and Dutch separately for boys and for girls. Laymen rated boys significantly more attractive than orthodontists. Young laymen, female laymen and Dutch laymen also rated the girls significantly more attractive than young, female, and Dutch orthodontists.

Differences in VAS score are shown in Table 3.3 for age within subgroups, laymen, orthodontists, males, females, Belgian, and Dutch separately for boys and girls. Older panel members rated boys significantly more attractive than younger panel members. There was no statistical difference between the ratings of older and younger panel members for the girls.

Table 3.2 *Visual analogue scale (VAS) means and standard deviation (SD) of the aesthetic scores for the photographs of boys, girls, and boys and girls taken together, given by laymen and orthodontists, young (under 46 years) and old (46 years and over) panel members, males and females, and Dutch and Belgian panel members.*

Panel members	***n***	**Mean VAS scores ± SD**		
		Boys	Girls	Both
Laymen	76	55.3 ± 5.8	52.6 ± 6.3	53.9 ± 5.7
Orthodontists	89	49.4 ± 6.8	50.6 ± 6.1	50.0 ± 6.2
Young	88	50.1 ± 6.9	50.9 ± 6.0	50.5 ± 6.1
Old	77	54.4 ± 6.3	52.2 ± 6.6	53.3 ± 6.1
Males	75	53.5 ± 6.0	52.7 ± 6.1	53.1 ± 5.7
Females	90	50.9 ± 7.5	50.6 ± 6.4	50.8 ± 6.6
Dutch	87	52.1 ± 6.9	52.0 ± 6.0	52.1 ± 6.2
Belgian	78	52.1 ± 7.1	51.0 ± 6.5	51.6 ± 6.4

Table 3.3 shows the differences in VAS score for gender within subgroups, laymen, orthodontists, young, old, Belgian, and Dutch separately for boys and for girls. Males rated the boys and girls more attractive than females. This finding was significant for all males, except for lay males. There was no significant difference between the ratings of male and female laymen.

Differences in VAS score are presented in Table 3.3 for geographical region within subgroups, laymen, orthodontists, young, old, males and females separately for boys and for girls. Belgian laymen rated the girls significantly less attractive than Dutch laymen. Belgian orthodontists rated the boys and the girls significantly more attractive than Dutch orthodontists. Older and female Belgian panel members rated the boys significantly more attractive than older and female Dutch panel members.

Significant first-order interactions were seen between gender and professional background ($P < 0.01$ for boys and for girls) and between region and professional background ($P < 0.01$ for boys and for girls). These interactions revealed that the difference between laymen and orthodontists is different for females versus males, and in Belgian versus Dutch panel members.

Table 3.3 *Difference in visual analogue scale (VAS) means in a multilevel model with all main effects. The P-values are corrected for multiple testing (Tukey-Kramer).*

	Boys		**Girls**	
	Difference in VAS	*P*-value	Difference in VAS	*P*-value
Laymen-orthodontists				
Young	5.1	< 0.01	1.8	< 0.01
Old	4.0	< 0.01	1.4	0.10
Males	2.6	< 0.01	0.2	0.97
Females	6.5	< 0.01	3.0	< 0.01
Belgian	2.2	< 0.01	-1.3	0.21
Dutch	6.9	< 0.01	4.5	< 0.01
Old-young				
Laymen	2.0	< 0.01	-0.1	0.99
Orthodontists	3.1	< 0.01	0.3	0.94
Males	2.9	< 0.01	0.2	0.99
Females	2.2	< 0.01	0.1	0.99
Belgian	3.1	< 0.01	-0.7	0.75
Dutch	2.0	< 0.01	0.9	0.31
Males-females				
Laymen	0.2	0.97	0.4	0.89
Orthodontists	4.2	< 0.01	3.2	< 0.01
Young	1.9	< 0.01	1.8	0.01
Old	2.6	< 0.01	1.8	0.02
Belgian	2.1	< 0.01	1.8	0.02
Dutch	2.4	< 0.01	1.7	< 0.01
Belgian-Dutch				
Laymen	-0.7	0.60	-3.4	< 0.01
Orthodontists	4.0	< 0.01	2.4	< 0.01
Young	1.1	0.15	0.3	0.9
Old	2.2	0.01	-1.3	0.2
Male	1.5	0.09	-0.5	0.9
Female	1.9	< 0.01	-0.6	0.7

As the between-subjects variance (*V*b) for the orthodontists was larger than for the laymen, the orthodontists used a larger part of the VAS for judging the group of adolescents. The within-subject variance (*V*w)

for the orthodontists was also larger than for the laymen. As a consequence, the orthodontists disagreed more than the laymen (Table 3.4).

Table 3.4 *Between-subjects variance (Vb) and within-subject variance (Vw) for laymen, orthodontists, and a mixed panel in the evaluation of the facial aesthetics of boys and girls.*

	***V*b**	***V*w**
Boys		
Mixed	94.10	163.89
Laymen	82.93	130.75
Orthodontists	127.44	169.74
Girls		
Mixed	126.28	156.28
Laymen	86.72	133.83
Orthodontists	172.55	163.20

In Table 3.5, the ICCs for panels of varying sizes from 1 to 10 are given. A random selection of seven panel members from a total of 165 led to an ICC of 0.80 and 0.85 for boys and girls, respectively.

Table 3.5 *Intraclass correlation coefficient for panels of size 1 to 10, separate for boys and girls, and within gender of the subjects separate for laymen, orthodontists, and mixed panels.*

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Boys										
Mixed	0.36	0.53	0.63	0.70	0.74	0.78	0.80	0.82	0.84	0.85
Laymen	0.39	0.56	0.66	0.72	0.76	0.79	0.82	0.84	0.85	0.86
Orthodontists	0.43	0.60	0.69	0.75	0.79	0.82	0.84	0.86	0.87	0.88
Girls										
Mixed	0.45	0.62	0.71	0.76	0.80	0.83	0.85	0.87	0.88	0.89
Laymen	0.39	0.56	0.66	0.72	0.76	0.80	0.82	0.84	0.85	0.87
Orthodontists	0.51	0.68	0.76	0.81	0.84	0.86	0.88	0.89	0.90	0.91

The ICC for the mean VAS score of seven randomly selected adult laymen from a total of 76 was 0.82 for boys and girls. A random selection of six orthodontists from a total of 89 resulted in an ICC of 0.82 and 0.86 for boys and girls, respectively. Based on the ICC, a panel of seven randomly selected laymen and/or orthodontists is sufficient to obtain reliable results in the aesthetic evaluation of adolescent faces, using photographs and a VAS.

3.4 Discussion

The lay panel was composed of males and females with a relatively high socio-economic status. This was justified since orthodontic treatment demand is higher in groups with a high socio-economic status than in those with a lower status, whereas the objective treatment need is similar in both groups.[14] Therefore, the lay panel can be assumed to be representative of that part of the general public assessing orthodontic treatment demand.

Since significant interactions were found, the results have to be considered separately for the different descriptors of the panel members.

Laymen rated the adolescents, especially boys, more attractive than orthodontists. As laymen are the end-users of orthodontic services, the opinion of laymen may have the most value in determining the appropriateness of aesthetic results.[15] Orthodontists should be aware of the fact that they are probably more critical about facial aesthetics than patients and their parents. They can use this information in their clinical practice and in communication with their patients on the treatment expectations.

In the present study, older panel members rated boys as more attractive than younger panel members. This suggests an ‘age effect’, meaning that, as people become older, they become less critical in judging facial aesthetics of boys. A ‘birth year effect’ is another possibility. This means that the older panel members were already less critical for boys when they were younger, as in the past, aesthetics in boys was considered less important than nowadays.

Male judges rated the adolescents more attractive than the female judges. Tedesco *et al.*[12] found that female laymen gave higher aesthetic scores than male laymen, but the panel used in that study consisted of only 12 college freshmen (three black females, three black males, three white females, and three white males). Therefore, their panel is probably not representative of the general public and conclusions on the influence of gender differences should be considered with caution.

Although Belgium and The Netherlands are neighbouring countries, and the panel members in this study speak the same language, several differences were found between the ratings of the Belgian and the Dutch sub-panels. Orthodontists working abroad must be aware of the fact that colleagues and patients from other countries might have a different perception of facial aesthetics.

The fact that differences were found between orthodontists and laymen, between older and younger panel members, between males and females, and between panel members from different countries does not mean that they do not agree on ranking facial aesthetics or on who is more beautiful and who is less. It simply means that some groups are more critical than others in the evaluation of facial aesthetics. In fact, in a previous study, high correlations were found between the aesthetic scores of the same laymen and orthodontists incorporated in the present study.[3] Orthodontists used a larger part of the VAS than laymen, and their VAS scores within the same subject differed more than those of laymen. In calculating the ICC, the difference in scoring between laymen and orthodontists was significant - laymen do not see much difference between the subjects but they agree more than orthodontists.

A panel of seven randomly selected laymen and/or orthodontists (males and/or females) is sufficient to yield reliable results, using the VAS as the outcome measure in clinical and epidemiological studies of facial aesthetics in adolescents. The use of smaller panels will lead up to less reliable results, while the use of larger panels is unnecessary, more time-consuming, and more expensive. However, panel characteristics have an influence on aesthetic evaluation. This means that for comparison of facial aesthetics in different groups of adolescents (e.g.

different centres), the same panel composition should be used, and this is also true when comparing the facial aesthetics of boys and girls.

3.5 Conclusions

The composition of a panel has a large impact on the aesthetic evaluation of adolescent faces, using photographs and a VAS. A panel of seven randomly selected laymen and/or orthodontists is sufficient to obtain reliable measurements of facial aesthetics.

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Chapter 4

Panel perception of change in facial aesthetics following orthodontic treatment in adolescents

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Summary

The aim of the study was to evaluate the influence of characteristics of panel members, the effects of gender and Angle Class of adolescent patients on their change in facial aesthetics following orthodontic treatment, and to assess the optimal panel size for epidemiological studies on changes in facial aesthetics after orthodontic treatment.

A panel of 74 adult laymen (35 males and 39 females) and a panel of 87 orthodontists (37 males and 50 females) evaluated post-treatment sets of three standardized photographs (one frontal, one three-quarter smiling, and one lateral) of 64 adolescent orthodontic patients in relation to the pre-treatment sets of the same patient on a 5-point scale.

The main effects of professional background, age, gender, and geographical region of the panel members on the aesthetic scores as well as their first-order interactions were evaluated by multilevel models. Professional background, age, gender, and geographical region of panel members have an influence on the evaluation of the change of facial aesthetics following orthodontic treatment.

The effect of gender and Angle Class of the patients on the scores was evaluated by two-way analysis of variance. There was no difference in the mean scores for boys and girls. Improvement of facial aesthetics by orthodontic treatment was significant for Class I, Class II division 1, and Class II division 2 patients, but not for Class III patients.

Based on the intraclass correlation coefficient, a panel of 9 randomly selected orthodontists, a panel of 14 randomly selected laymen, or a mixed panel of 13 individuals is sufficient to obtain reliable results in the aesthetic evaluation of adolescent faces, using photographs and a 5-point scale.

4.1 Introduction

The major reason why people seek orthodontic treatment is improvement of facial aesthetics.[1,2] Parents of young orthodontic patients expect that orthodontic treatment will improve the dental, dentofacial, and facial aesthetics of their children.[3] Orthodontists also consider improvement of facial aesthetics as an important treatment goal, and therefore, it is an important issue in their decision-making process and their treatment plans.[4,5] The opinion of the general public, the end-users of orthodontic services, may have the most value in determining the appropriateness of aesthetic results.[5] However, the question arises as to whether the general public appreciates facial change brought about by orthodontic treatment (and growth) the same way as orthodontists. Literature on the subject is rare and mostly deals with orthognathic surgery.[6,7] The few investigations on panel evaluation of facial aesthetics after orthodontic treatment have focussed on different treatment modalities. In those studies, comparisons were made between extraction versus non-extraction,[8] different types of functional appliances versus non-treatment,[9] and orthognathic surgery versus non-surgical interventions.[10] Only Kerr and O'Donnell[11] evaluated differences in facial aesthetics in orthodontic patients, before and after treatment, as judged by four panels: art students, parents of children undergoing orthodontic treatment, dental students, and orthodontists. However, a drawback of that study was that Class II division 2 patients were not included, and that the panels consisted of only four persons per panel, which might be too small to draw reliable conclusions. Another problem in panel evaluation of facial aesthetics is that differences in panel composition concerning age and gender may be confounders.[12]

No publications are available on regional differences of panel members, assessing the change in facial aesthetics by orthodontic treatment in adolescents. This subject, however, can be of interest for orthodontists moving to other regions. Orthodontists working all over the world, evaluating their own treatment outcomes, should know whether they agree with their patients and their parents. They can benefit from this knowledge in their patient discussion on treatment expectations.

Panel size is another issue to be investigated. Howells and Shaw[13] found that for the evaluation of facial aesthetics, good reliability was established with a two-person panel, but that an increase in panel size would improve the reliability. However, the optimal size of such a panel has never been established.

Since there is so little known about these topics, the aims of the present study were as follows:

a. evaluation of the influence of, and the possible interactions between, professional background, age, gender, and geographical region of panel members on their perception of change in facial aesthetics following orthodontic treatment;
b. evaluation of possible effects of gender and Angle Class of adolescent patients on their change in facial aesthetics following orthodontic treatment; and
c. to find indications for an optimal panel size for clinical and epidemiological investigations on the change in facial aesthetics following orthodontic treatment.

4.2 Materials and methods

Sets of three standardized colour photographs (one frontal, one three-quarter smiling, and one lateral) of Caucasian patients from the 1990-2000 files of the Department of Orthodontics and Oral Biology of the Radboud University Nijmegen Medical Centre, The Netherlands, were selected. The inclusion criteria were age between 10 and 16 years during complete orthodontic treatment, treatment time duration up to 3.3 years, not wearing eye glasses, no dental or facial trauma, or any known congenital defects. This treatment duration was chosen, since the average treatment time at the Department of Orthodontics, Radboud University Nijmegen, is approximately 3.3 years. From this group, which comprised 764 patients, 64 patients were randomly selected after stratification for gender and Angle Class. The stratification was performed in order to obtain a wide variation of dental/skeletal characteristics and an equal gender distribution. Angle Classifications were defined as follows: Angle

Class I: neutro-occlusion and neutro-relationship of the jaws; Class II division 1: disto-occlusion and disto-relationship of the jaws, with proclined upper incisors; Class II division 2: disto-occlusion and disto-relationship of the jaws, with retroclined upper incisors; and Class III: mesio-occlusion and mesio-relationship of the jaws. The stratification aimed for approximately eight boys and eight girls for each of the four Angle Classes. The distribution of gender and Angle Class is given in Table 4.1. Neither the severity of the malocclusion nor the chosen treatment modality was important for this study, since the aim was to determine only the change in facial aesthetics after orthodontic treatment.

Table 4.1 *Distribution of patients over gender and Angle Classes.*

	Class I	**Class II division 1**	**Class II division 2**	**Class III**	**Total**
Boys	7	9	8	8	32
Girls	8	9	8	7	32
Total	15	18	16	15	64

For each individual, a set of digitized images was prepared, showing simultaneously a frontal, a three-quarter smiling, and a lateral view before treatment and also a set of such images after treatment. These sets of images were used as stimuli in a panel evaluation. For that purpose, a panel of 76 adult laymen with a relatively high socio-economic status from Belgium and the Netherlands, and a panel of 89 orthodontists (85 orthodontists and 4 postgraduates) from the same regions were empanelled. They evaluated the differences in facial aesthetics pre- and post-treatment of the 64 patients on a 5-point scale in which: –2 = markedly worsened, –1 = worsened, 0 = no change, +1 = improved, and +2 = markedly improved. The photographs of each patient were displayed for 15 seconds. In order to evaluate intra-individual reproducibility of the measuring system, six duplicate sets of patients were randomly inserted into the series.

4.3 Statistics

Statistical analysis was performed on the ratings of a final panel of 74 laymen and 87 orthodontists. The ratings of two laymen and two orthodontists were excluded because of missing data. Distribution of geographical region, gender, and age of both panels is given in Table 4.2.

Table 4.2 *Distribution of geographical region, gender (m=males, f=females), and age (years) of laymen and orthodontists in the panels.*

Panel members	***n***	**Age (years)**		
		Mean ± SD	Median	Range
Laymen				
Dutch	39 (23m, 16f)	53.9 ± 8.6	52	39-74
Belgian	35 (12m, 23f)	48.0 ± 10.7	47	28-76
Orthodontists				
Dutch	45 (28m, 17f)	46.7 ± 8.3	45	32-65
Belgian	42 (9m, 33f)	37.3 ± 6.4	38	25-53

SD, standard deviation

Means and standard deviations (SDs) of the ratings for each set of photographs were calculated per panel, per age, per gender, and per geographical region. The number of observations of laymen (74) and orthodontists (87) was large enough to consider the data normally distributed.

In the statistical evaluation of the reproducibility of the ratings on the 5-point scale, the random error for a rater was calculated as $SD/\sqrt{2}$, with SD = the SD of the differences of the duplicated photographs.

Pearson's correlation coefficients were used to determine the individual reliability using the median of all raters for the six sets of duplicate measurements.

The influence of professional background, age, gender, and geographical region of the panel members on the 5-point scale for boys and girls separately and their first-order interactions were tested within the framework of multilevel models. Second-order and higher order

interactions are difficult to interpret and therefore only the model with the four main effects and first-order interactions is presented. Analyses were performed, using 'Proc Mixed' in SAS 8.0 (SAS^R Software, SAS Institute Inc., Cary, North Carolina, USA). For this purpose age was dichotomized at 46 years, which was the median age of the panel members.

A two-way analysis of variance (ANOVA) was performed on the mean ratings of laymen and orthodontists separately, in order to evaluate the effect of gender and Angle Class of the patients on the ratings.
The reliability for the final score was expressed as the intraclass correlation coefficient (ICC). The subjects (adolescents) were entered as a random effect in the analysis. Variance of the random effects, Vb, is the between-subjects variance and reflects the variability of the 5-point score between subjects. The within-subject variance, Vw, reflects the variability of the panel members over the same subject. The ICC is then given by Vb/[Vb + Vw], which can be interpreted as the mean correlation of randomly selected pairs of single panel members. The ICC is 1 when all panel members agree perfectly on all subjects. When the within-subject variance is large (panel members substantially disagree on the same subject) compared with the between-subjects variance, the ICC is close to 0. The 5-point score can be considered to be a reliable measure if the ICC is equal to or above 0.80. When the 5-point score is based on the average 5-point scores of N randomly selected raters, the ICC for pairs of panels is ICC(N) = N x ICC(1)/[1 + (N – 1) x ICC(1)].

The optimal panel size was found by choosing the smallest value of N where ICC(N) was equal to or above 0.80 for girls as well as for boys.

4.4 Results

All mean scores were normally distributed. Means and SDs of the 5-point scores for boys and for girls, given by laymen and orthodontists, young (under 46 years) and old (46 years and over) panel members, males and females, and Dutch and Belgian panel members are shown in Table 4.3.

Table 4.3 *Means and standard deviation (SD) of the scores on the 5-point scale for the photographs of boys, girls, and boys and girls taken together, given by laymen and orthodontists, young (under 46 years) and old (46 years and over) panel members, males and females, and Dutch and Belgian panel members.*

Panel members	***n***	**Mean 5-point scores ± SD**		
		Boys	Girls	Both
Laymen	74	0.43 ± 0.25	0.51 ± 0.29	0.47 ± 0.25
Orthodontists	87	0.37 ± 0.22	0.51 ± 0.22	0.44 ± 0.21
Young	85	0.37 ± 0.21	0.51 ± 0.21	0.44 ± 0.19
Old	76	0.43 ± 0.25	0.51 ± 0.30	0.47 ± 0.26
Males	72	0.42 ± 0.23	0.49 ± 0.26	0.45 ± 0.23
Females	89	0.37 ± 0.24	0.53 ± 0.24	0.45 ± 0.23
Dutch	84	0.47 ± 0.20	0.55 ± 0.25	0.51 ± 0.21
Belgian	77	0.31 ± 0.24	0.47 ± 0.25	0.39 ± 0.23

The random errors for the different photographs varied over the laymen from 0.5 to 0.8 points and over the orthodontists from 0.4 to 0.7 points. The mean of the differences of the duplicate measurements varied from –0.8 to 0.4 and –0.6 to 0.8, respectively.

The median correlation coefficient (individual reliability) was 0.69 (P25 = 0.39; P75 = 0.82) for the laymen and 0.87 (P25 = 0.75, P75 = 0.93) for the orthodontists.

The influence of professional background, age, gender, and geographical region on the 5-point scale for boys and girls is shown in Table 4.4. Significant differences were found for older, female, and Dutch laymen, who found more facial aesthetic improvement after orthodontic treatment in boys than comparable orthodontists. Younger panel members evaluated the change in facial aesthetics in boys and girls the same as older panel members. Lay females and Dutch females found more facial aesthetic improvement in girls than comparable males. Dutch panel members found more facial aesthetic improvement in boys than Belgian panel members. In girls, this finding was significant for lay, older, and female Dutch panel members.

Table 4.4 *Difference of 5-point means in a multilevel model with all mean effects. The P-values are corrected for multiple testing (Tukey-Kramer).*

	Boys		**Girls**	
	Difference in 5-point score	*P*-value	Difference in 5-point score	*P*-value
Laymen-orthodontists				
Young	-0.02	0.91	-0.01	0.99
Old	0.13	< 0.01	0.03	0.83
Males	0.005	1.00	-0.03	0.78
Females	0.11	< 0.01	0.05	0.38
Belgian	0.004	1.00	-0.05	0.53
Dutch	0.11	< 0.01	0.07	0.14
Old-young				
Laymen	0.07	0.19	-0.001	1.00
Orthodontists	-0.09	0.09	-0.04	0.64
Males	-0.003	1.00	-0.04	0.69
Females	-0.01	0.98	-0.003	1.00
Belgian	-0.06	0.38	-0.09	0.14
Dutch	0.04	0.52	0.04	0.58
Males-females				
Laymen	-0.05	0.33	-0.12	< 0.01
Orthodontists	0.05	0.45	-0.03	0.82
Young	-0.007	1.00	-0.05	0.39
Old	0.002	1.00	-0.09	0.07
Belgian	0.07	0.22	-0.06	0.36
Dutch	-0.07	0.10	-0.09	0.04
Belgian-Dutch				
Laymen	-0.22	< 0.01	-0.17	< 0.01
Orthodontists	-0.11	0.01	-0.05	0.54
Young	-0.11	< 0.01	-0.05	0.50
Old	-0.22	< 0.01	-0.18	<0.01
Males	-0.10	< 0.05	-0.10	0.07
Females	-0.24	< 0.01	-0.13	< 0.01

For the boys, significant first-order interactions were found between professional background and gender ($P = 0.03$), professional background

and region ($P = 0.04$), professional background and age of the raters ($P < 0.01$), region and gender ($P < 0.01$), and region and age of the raters ($P < 0.05$). For the girls, significant first-order interactions were found between region and professional background ($P = 0.03$) and between region and age of the raters ($P = 0.02$).

Table 4.5 *Mean improvement and Standard Deviation (± SD) of facial aesthetics over the Angle Classes (pooled data for boys and girls) as assessed by laymen and orthodontists.*

Panel	Class I	Class II division 1	Class II division 2	Class III
Laymen	0.56 ± 0.46*	0.68 ± 0.50*	0.47 ± 0.40*	0.14 ± 0.46
Orthodontists	0.42 ± 0.46*	0.64 ± 0.60*	0.51 ± 0.45*	0.14 ± 0.39

* = Significant improvement $P < 0.002$.

Two-way ANOVA showed no interactions between gender and Angle Class of the adolescents (interaction tests for both panels $P > 0.13$). There was no difference in mean change in facial aesthetics between the boys and the girls, and therefore, their data were combined for evaluation of the influence of Angle Class. Both panels scored a significant improvement after orthodontic treatment for Class I, Class II division 1, and Class II division 2 patients (all $P < 0.002$). Class III patients did not significantly improve ($P > 0.20$ for both panels) (Table 4.5).

Table 4.6 *Between-subject variance (Vb) and within-subject variance (Vw) for laymen and orthodontists in the evaluation of changes in facial aesthetics of boys and girls and intraclass correlation coefficient (ICC) between two panels, each consisting of one randomly selected rater.*

	***V*b**	***V*w**	**ICC**
Boys			
Laymen	0.29	0.56	0.34
Orthodontists	0.27	0.44	0.38
Girls			
Laymen	0.17	0.58	0.22
Orthodontists	0.22	0.46	0.32

The ICC for two panels, each consisting of one randomly selected layman, judging boys was 0.34 and 0.22 in judging girls. The ICC for two panels, each consisting of one randomly selected orthodontist, when judging boys was 0.38 and 0.32 when judging girls (Table 4.6). The ICC was higher for the orthodontists than for the laymen. As *V*w was considerably smaller for orthodontists than laymen, the orthodontists agreed more over the same adolescent than the laymen (Table 4.6).

The ICCs for panels with varying size are shown in Table 4.7. A panel of 9 randomly selected orthodontists, a panel of 14 randomly selected laymen, or a mixed panel of 13 laymen and orthodontists, fulfil the prerequisite of an ICC equal or above 0.80 both for boys and girls. These panel sizes are sufficient to obtain reliable results in the evaluation of the aesthetic change in adolescent faces, using photographs and a 5-point scale.

Table 4.7 *Intraclass correlation coefficient (ICC) for panels of size 5 to 15, for boys and girls separate for laymen, orthodontists, and for mixed panels.*

	Panel size	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
ICC for Boys	Mixed	0.69	0.73	0.76	0.78	0.80	0.82	0.83	0.84	0.85	0.86	0.87
	Laymen	0.72	0.76	0.78	0.80	0.82	0.84	0.85	0.86	0.87	0.88	0.89
	Orthodontists	0.75	0.79	0.81	0.83	0.85	0.86	0.87	0.88	0.89	0.90	0.90
ICC for Girls	Mixed	0.61	0.65	0.69	0.72	0.74	0.76	0.78	0.79	0.80	0.82	0.83
	Laymen	0.59	0.63	0.67	0.70	0.72	0.74	0.76	0.78	0.79	0.80	0.81
	Orthodontists	0.70	0.74	0.77	0.79	0.81	0.83	0.84	0.85	0.86	0.87	0.88

4.5 Discussion

The lay panel in the present study was composed of males and females with a relatively high socio-economic status. This was justified since orthodontic treatment demand is higher in groups with a higher socio-economic status than in those with a lower status, whereas the objective treatment need is similar in both groups.[14] Therefore, such a lay panel can

be assumed to be representative for the general public most concerned with orthodontic treatment demand.

Since the average treatment duration in the Department of Orthodontics, Radboud University Nijmegen, is approximately 3.3 years, the treatment duration of the patients was up to 3.3 years. The findings of this study must be seen as a change brought about by a combination of orthodontic treatment and growth, since it is impossible to analyse these two separately.

In this study, laymen and orthodontists saw an aesthetic improvement following orthodontic treatment in Class I, Class II division 1, and Class II division 2 patients. This aesthetic improvement was significant. However, it should be borne in mind that this improvement was only significant at the group level and not for each individual. As shown in Table 4.5, the mean improvements seen in Class I, Class II division 1, and Class II division 2 patients were in the range of 0.42 - 0.68 points. Whether this value is clinically relevant is a subjective matter. As suggested by McComb *et al*.,[3] the expectations of parents of patients and of dentists, referring the patients, are over-optimistic. Therefore, orthodontists should be aware of the fact that expectations of patients and their parents can only be fulfilled to a certain degree. Especially for Class III patients, in which no significant improvement of facial aesthetics after treatment was found, orthodontists should be cautious with promises of aesthetic improvement.

In a previous study, in which the same laymen and orthodontists as in the present investigation were empanelled, the influence of panel characteristics on the aesthetic evaluation of boys and girls before treatment has been investigated.[15] However, comparison of the results of both studies is not justified, since in the present investigation the perception of change in facial aesthetics was evaluated, not the aesthetic preferences themselves.

In the present research, it was found that some subgroups of laymen, in judging boys, were more aware of aesthetic improvement than comparable subgroups of orthodontists. This is in contrast to the findings of Kerr and O'Donnell.[11] The panels used in that study, however, consisted of only four members. These panels may not be representative

of the general public or of orthodontists and therefore their ratings should be considered with caution.

Dutch panel members found more aesthetic improvement after orthodontic treatment than Belgian panel members. All panel members in this study spoke the same language and lived in neighbouring countries. However, cultural differences between the countries exist and the finding from the present study might be an expression of such differences. Orthodontists working overseas must be aware of the fact that colleagues and patients and their parents from other countries might see more or less aesthetic improvement than themselves. Therefore, it is advocated that orthodontists working overseas communicate extensively with patients and their parents on their expectations of orthodontic treatment.

Panel characteristics have an influence on aesthetic evaluation. Differences in opinion were found in the different subgroups and several first-order interactions became apparent, indicating that the composition of a panel is extremely important in the evaluation of changes in facial aesthetics following orthodontic treatment. Therefore, it should be a major concern when comparing results of studies using different panels.

For evaluation of facial aesthetics, different panel sizes and different measurement techniques are found in the literature.[6,7,9-11,13] It is surprising that so little is known on optimal panel size. If the optimal panel size is defined as the smallest panel that gives reliable results, calculation of the ICC is an appropriate tool. In the present study, the panel size was assumed to be optimal if the ICC was equal to or above 0.80. The use of smaller panels will lead to less reliable results, while the use of larger panels is unnecessary, more time-consuming, and more expensive.

Panel sizes of at least 9 randomly selected orthodontists, or 14 randomly selected laymen or a mixed panel of 13 raters are sufficient to yield reliable results, using a 5-point scale as the outcome measure on change in facial aesthetics in adolescents. In a previous investigation on facial aesthetics, using a visual analogue scale (VAS) as the outcome measure, it was found that a panel of seven randomly selected laymen and/or orthodontists could give reliable results.[15] This indicates that the optimal panel size is dependent on the measurement technique.

4.6 Conclusions

Professional background, age, gender, and geographical region of panel members have an influence on their evaluation of changes in facial aesthetics after orthodontic treatment. Panels with equal characteristics should be used for mutual comparison in different groups of patients.

Improvement of facial aesthetics after orthodontic treatment was seen in Class I, Class II division 1 and Class II division 2 patients.

In order to obtain reliable results of changes in facial aesthetics using photographs and a 5-point scale, the panel should consist of at least 9 randomly selected orthodontists, 14 randomly selected laymen, or if a mixed panel is used, it should consist of at least 13 members.

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Chapter 5

Objective measures as indicators for facial aesthetics in White adolescents

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Summary

The objective of this study was to examine the contribution of objective measures representing anterior-posterior and vertical characteristics, dental aesthetics, or their combination that are used in daily orthodontic practice in the assessment of facial aesthetics. A panel of 78 laymen evaluated facial aesthetics of 32 boys and 32 girls, stratified over the four Angle Classes, on a visual analogue scale. The relation between the objective parameters and facial aesthetics was evaluated by backward multiple regression analysis. Dental aesthetics as expressed by Aesthetic Component of the Index of Orthodontic Treatment Need (AC/IOTN) appeared to be the most important indicator for facial aesthetics. A new parameter, the ‘horizontal sum’ was found to be a reliable variable for the anterior-posterior characteristics of the patient. Addition of this newly defined parameter to the AC/IOTN improved the prognostic value from 25% to 31%.

5.1 Introduction

Orthodontic treatment for aesthetic reasons is a sign of the times.[1] Orthodontic patients and their parents believe that well-aligned teeth are important for overall facial appearance.[2,3] They expect that orthodontic treatment will improve their dental, dentofacial and facial aesthetics[1,3-6] and consequently their popularity and social acceptance.[7-10] Therefore, over the last decades orthodontists focus their treatment plans more and more on improvement of facial aesthetics.[11]

Our society seems to have an implicit standard for facial aesthetics.[12] Both orthodontists and laymen are very well able to use VAS scores to judge facial aesthetics from photographs in a more or less intuitive way although facial aesthetics seems to be a subjective and a not well-defined variable.[13-17] For patients, to a large extent, the expectations of an orthodontic treatment depend on the perception of their own (dento)facial aesthetics[18] and on the constant judgment by their peers. The decision of teenagers to undergo orthodontic treatment seems to be motivated by social norms and the beauty culture in their reference group and the society in general.[1] This means that the opinions of laymen are the important parameter in determining the success of an orthodontic treatment.[11]

Orthodontists prefer to use objective parameters instead of opinions for their diagnosis, their treatment plan, and evaluation of the outcome of their clinical intervention. Their treatment plans are often aimed at changing these objective parameters to meet standards of normality. Objective parameters used by orthodontists mainly focus on a quantitative description of anterior-posterior and vertical discrepancies and dental irregularities.

The most commonly used parameter for anterior-posterior characteristics is the Angle Classification. This is a very rough estimate that consists of only four discrete classes. Not surprisingly, the use of this classification for facial appreciation has led to conflicting results.[15,17,19-24]

Some authors focus on dental measurements such as molar relationship or overjet as separate parameters. Because the molar relationship is not reflected in the face, overjet seems to be the most

appropriate measure related to facial attractiveness.[25] Other authors focus on skeletal measurements, the ANB angle in particular, as determinants for anterior-posterior characteristics. This angle shows a wide range of values over the different Angle Classes because it is not only related to the position of point A and B, but also to the position of point N and the rotation of the jaws relative to the SN-line.[26] For a proper evaluation of the anterior-posterior characteristics of the face of a patient, a combination of overjet and ANB angle might be indicated.

The effect of vertical characteristics on facial attractiveness has mainly been studied on constructed profiles[19,27] or manipulated photographs,[24,28,29] but their contribution in profile preferences is still unclear. Most orthodontists use the SN-GoGn angle for the evaluation of vertical dimensions in daily clinical practice, but as far as we know, this parameter has never been related to facial attractiveness.

The importance of dental irregularities or dental relationships in whole facial attractiveness has been illustrated by many authors.[2-10] Some of them evaluated the social attractiveness of children as judged on photographs in which they had manipulated the arrangement of the front teeth using computer techniques.[2,8] Faces with a normal dental appearance were judged to be the most attractive. Nowadays, the Aesthetic Component of the Index of Orthodontic Treatment Need (AC/IOTN) as described by Evans and Shaw[30] is widely accepted for the evaluation of dental aesthetics.

Despite extensive research on facial aesthetics, no attempt has been made to relate the layperson's perception of facial aesthetics to objective facial and dental parameters. This seems to be important because aesthetics is the main reason to seek orthodontic treatment. Therefore, the aim of this study was to determine which objective measures as used in daily orthodontic practice are related to facial aesthetics as perceived by laymen. These measures represent dental and skeletal anterior-posterior characteristics (overjet and ANB angle, respectively), skeletal vertical characteristics (SN-GoGn angle), and dental aesthetics (AC/IOTN) separately or in combination.

5.2 Materials and methods

5.2.1 Patient selection

The 1990-2000 files of the Department of Orthodontics and Oral Biology of the Radboud University Nijmegen Medical Centre, The Netherlands, were searched for White children meeting the following inclusion criteria: age 10 to 16 years, without dental or facial trauma or known congenital defects, and not wearing glasses. Suitable pre-treatment records should be available: dental casts, cephalograms, intraoral and extraoral color photographs (including frontal, lateral and three-quarter smiling).

A total of 764 patients (366 males and 398 females) met the inclusion criteria. From this group, 64 patients were randomly selected after stratification to have about eight boys and eight girls for each of the four Angle Classes. This stratification was performed in order to have a wide range of dental/skeletal variation. The Angle Classes were defined as follows: Angle Class I, neutro-occlusion and neutro-relationship of the jaws; Class II division 1, disto-occlusion and disto-relationship of the jaws, with proclined upper incisors; Class II division 2, disto-occlusion and disto-relationship of the jaws, with retroclined upper incisors; and Class III, mesio-occlusion and mesio-relationship of the jaws.

5.2.2 Facial aesthetics

Facial aesthetics was judged by a panel of 78 adult laymen (38 men and 40 women, mean age: 51 ± 10.3 years; range 28 to 76 years). The panel members had different professional backgrounds and a relatively high socio-economic status. This panel judged facial attractiveness of the selected patients as described previously.[17] In brief, for each individual, a set of digital images was prepared, simultaneously showing a frontal, a three-quarter smiling with visible front teeth and a profile view. These sets of photographs, presented in random order as a slide show, were to be assessed on a visual analogue scale (VAS) from 0 (= very unattractive) to 100 (= very attractive) in relation to reference sets, one for boys and one for girls on which the predetermined VAS values were indicated.

Each reference set had been selected previously as the median of a panel evaluation performed by 49 dental students (aged 18 to 26 years). For this selection, 40 photographs of boys and 40 photographs of girls were used, which were randomly selected from the files of the Department of Orthodontics and Oral Biology of the Radboud University Nijmegen Medical Centre, The Netherlands, and who met the inclusion criteria. This scoring method with one reference set for boys and one for girls has been shown to be valid and reproducible.[17] Each face was shown for 15 seconds. To evaluate the reproducibility of the measurements, six duplicate sets of photographs were randomly inserted into the series.

5.2.3 Objective parameters

For each individual, the following objective parameters were determined on the available patient documentation.

- Overjet was measured on the dental casts as the anterior-posterior distance between the maxillary and mandibular central incisors at the most labial point of the most prominent incisor.
- ANB angle and SN-GoGn angle were measured on tracings of the lateral head films.
- AC/IOTN was determined according to the guidelines of Evans and Shaw[30] on the intraoral photographs by mutual agreement between two independent observers.

5.2.4 Statistics

The VAS scores of two panel members were not used for statistical analysis because of missing data. For the remaining panel members, the random error of the six duplicated photographs was calculated by Dahlberg statistics.

For each individual set of photographs, the mean and standard deviation (SD) of the ratings on the VAS were calculated as the final aesthetic score.

Initial analysis revealed a coliniarity (Pearson's correlation coefficient = 0.74) of the two parameters describing the anterior-posterior characteristics, namely overjet and ANB angle, on the VAS scores, leading to noninterpretable influences. Therefore, the two variables were

combined into a new parameter for the estimation of horizontal characteristics. This new parameter was defined as the sum of ANB (in degrees) and overjet (in millimetres), and is called ‘horizontal sum’. Cronbach’s alpha was calculated to determine the reliability of this "horizontal sum". Cronbach’s alpha is a useful coefficient for assessing internal consistency. The reliability of a scale is generally regarded as satisfactory if its value is ≥ 0.80.[31]

The relation between horizontal sum, SN-GoGn angle, and AC/IOTN at one side and the VAS score at the other side was analyzed by backward multiple regression analysis. Because horizontal sum and SN-GoGn angle may have an optimal value, quadratic regression analysis also was performed for these parameters. The explained variance (adjusted r^2) was calculated.

5.3 Results

The parameter horizontal sum, which was the sum of overjet in millimetres and ANB angle in degrees, constituted a reliable scale for the horizontal characteristics of a patient (Cronbach’s alpha $\alpha = 0.84$).[31] The ranges of the objective parameters overjet, ANB angle, horizontal sum, SN-GoGn angle, and AC/IOTN as determined in the different Angle Classes are summarized in Table 5.1.

Table 5.1 *Ranges of facial features Overjet, ANB angle, SN-GoGn angle, and AC/IOTN over the different Angle Classes among the sample (N = 64).*[*]

Angle Class	Overjet (mm)	ANB (º)	Horizontal Sum	SN-GoGn (º)	AC/IOTN
Class I	0 to 7	-1 to 5	0 to 10	25 to 42	1 to 7
Class II division 1	6 to 14	4 to 8	11 to 19	24 to 47	1 to 9
Class II division 2	1 to 7	2 to 7	5 to 13	22 to 36	1 to 8
Class III	-3 to 5	-5 to 1	-7 to 3	28 to 44	2 to 9
Total	-3 to 14	-5 to 8	-7 to 19	22 to 47	1 to 9

[*] *AC/IOTN indicates Aesthetic Component of the Index of Orthodontic Treatment Need.*

The random error of the VAS scores in the duplicate sets of photographs varied from two to 17 VAS points. The median random error was 6.8 VAS points. The median individual reliability was sufficiently high (0.68). Means and SDs of the aesthetic scores on the VAS according to gender and Angle Class are summarized in Table 5.2.

Table 5.2 *Mean ± SD of the aesthetic scores given by laymen on the VAS according to gender and Angle Class of the subjects.*[*]

Angle Class	**Boys (n = 32)**		**Girls (n = 32)**	
	n	Mean ± SD	n	Mean ± SD
Class I	8	52.6 ± 7.8	7	56.8 ± 6.1
Class II division 1	9	55.8 ± 11.3	9	51.9 ± 11.5
Class II division 2	8	60.4 ± 4.6	8	55.2 ± 4.3
Class III	7	51.7 ± 9.4	8	47.2 ± 11.6
Total	32	55.3 ± 8.9	32	52.6 ± 9.5

[*] *SD indicates standard deviation; VAS, visual analogue scale.*

Backward multiple regression analysis showed that SN-GoGn angle was not significantly correlated with the VAS scores ($P = 0.70$). The parameter AC/IOTN showed a significant negative correlation with the VAS scores (adjusted $r^2 = 0.25$; $P < 0.001$) (Figure 5.1). Horizontal sum ($P = 0.002$) and its quadratic value ($P = 0.005$) together showed a significant influence on the VAS scores (adjusted $r^2 = 0.13$, $P = 0.006$). The corresponding parabola showed a maximum at 8.6 (95% confidence interval 5.6 - 11.6) (Figure 5.2).

If all three parameters (horizontal sum, quadratic horizontal sum, and AC/IOTN) were taken together, the explained variance amounted to 31%.

5.4 Discussion

Facial aesthetics was judged on a series of sets of three photographs of 64 patients according to Kiekens *et al.*[17] The judgments were performed by a

panel of laymen with a relatively high socio-economic status. These laymen were considered as representative for the part of the general public, that shows the highest orthodontic treatment demand.[32,33]

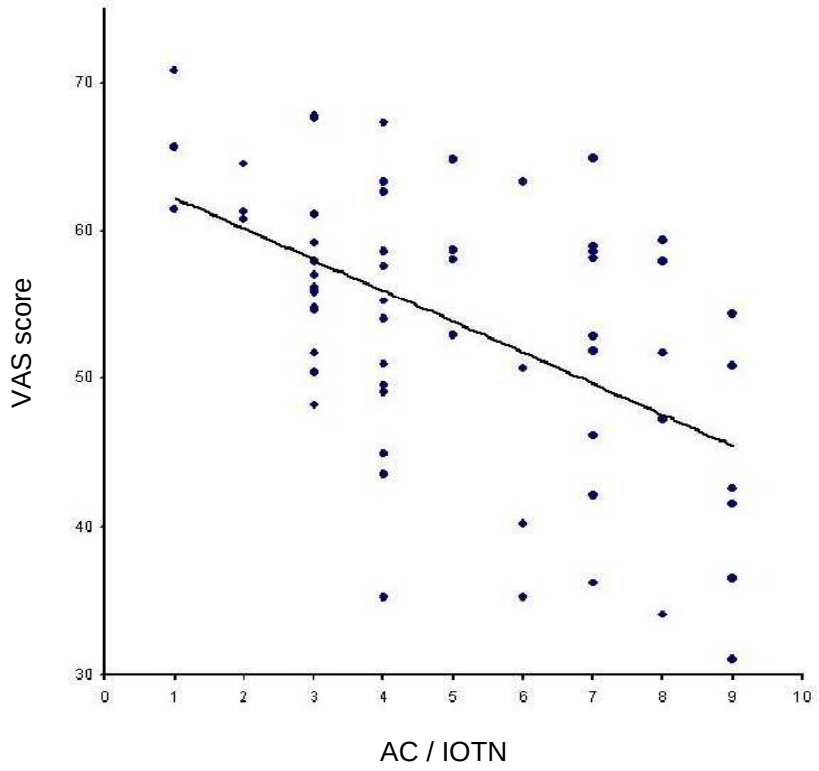

Figure 5.1 *Relation between AC/IOTN and VAS scores. VAS indicates visual analogue scale; AC/IOTN, Aesthetic Component of the Index of Orthodontic Treatment Need.*

The stimulus used in the present study consisted of a stratified sample of Angle Class I, II/1, II/2, and III patients. This stratification was only performed to have a wide range of dental/skeletal variation, covering the whole spectrum of orthodontic patients. The objective parameters used in the present study showed wide overlapping ranges for the different Angle Classes. This indicates that none of them was decisive for the Angle Classification. Also, the VAS scores showed a wide and overlapping range in all of the Angle Classes.

The new parameter, horizontal sum as introduced in this study, is a reliable and simple measurement for the horizontal components related to the dentition (overjet) measured on the dental casts and to the skeleton (ANB angle) measured on the lateral radiographs. Laymen gave the highest VAS scores on faces with a horizontal sum value of 8.6. Because

orthodontists consider an overjet of 2 mm and an ANB angle of 2° as normal in Caucasians, laymen apparently prefer slightly convex faces.

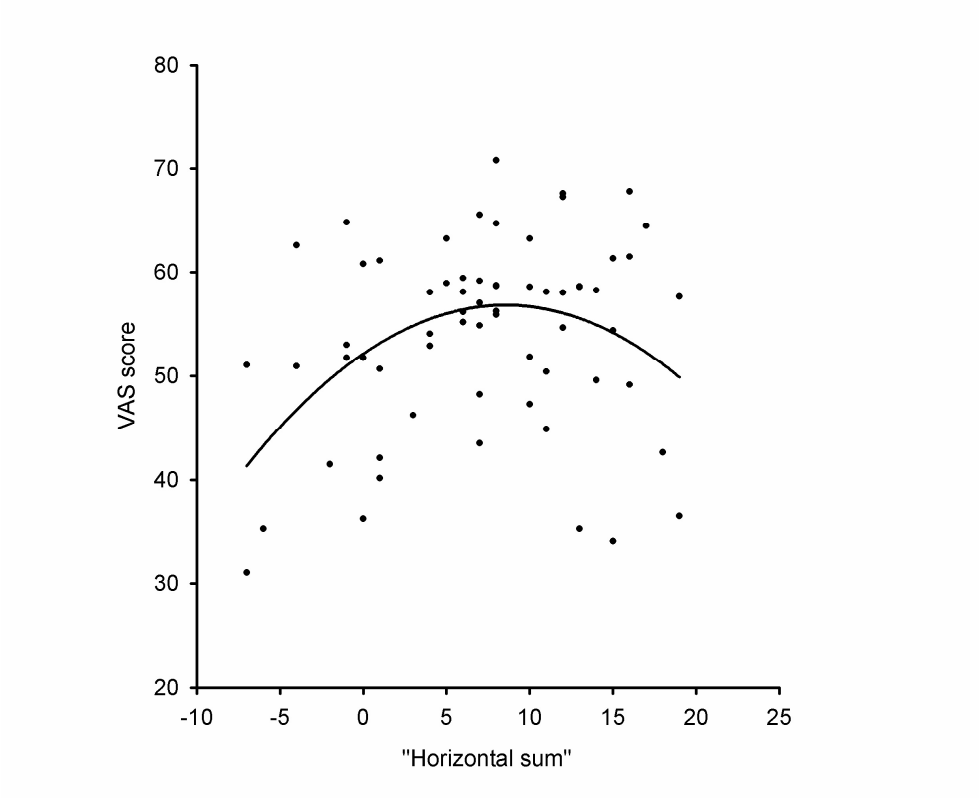

Figure 5.2 *Relation between 'horizontal sum' and VAS score with top of regression line at 8.6. VAS indicates visual analogue scale.*

The fact that for the variable horizontal sum, degrees and millimetres are summed, might be surprising, but it appears to be a reliable parameter (Cronbach's alpha = 0.84). The Wits-appraisal[26] that is measured in millimetres could have been used as an alternative to the ANB angle. However, it has the drawback that it is measured as a distance on cephalograms and that its value therefore depends on the magnification of the radiographs. On the other hand, the Wits-appraisal measures exclusively the horizontal characteristics, whereas the horizontal sum, which comprises the ANB angle, is also influenced by the vertical position of the points N, A, and B.[26] For a same position of point A and B, a lower position of point N, results in a larger ANB angle. The fact that a horizontal sum value of 8.6 was preferred could indicate that in case of a short face (lower position of point N, larger ANB angle)

laymen prefer faces with a small overjet. However, in long faces (higher position of point N, smaller ANB angle) they may prefer larger overjets.

The SN-GoGn angle was not significantly related to the aesthetic scores. SN-GoGn angle is often used as an indicator for facial height, but in fact it is a measure for mandibular rotation or growth direction, not for facial height. Lundström *et al.*[34] found patients with a vertical growth direction the least attractive. However, the N-S-Gn angle as indicator for growth direction[34,35] is also influenced by the vertical as well as the horizontal position of the chin (Gn). Facial convexity and facial height are mutually related, which is probably the reason why in some investigations and also in our investigation, the contribution of facial height to facial attractiveness is a matter of discussion.[23,28,29]

The AC/IOTN, which is a measure for dental aesthetics, appears to be the most important contributor to the appreciation of facial aesthetics because this parameter alone leads to an explained variance of 25%. The other parameters used in this study were less important. The addition of the horizontal sum to the AC/IOTN resulted in an increase of the explained variance from 25% to 31%. Although this improves the prognostic value, it is important to realize that the remaining 69% of the variance is left unaccounted for by these parameters and probably has to be attributed to other facial features such as eyes, skin and hair.

5.5 Conclusions

Of the parameters used in this study, dental aesthetics as expressed by the AC/IOTN appeared to be the most important indicator for facial aesthetics.

Addition of the newly defined parameter horizontal sum improved the prognostic value from 25% to 31%.

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Chapter 6

Putative golden proportions as predictors for facial aesthetics in adolescents

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Summary

Introduction: In orthodontics, facial aesthetics is assumed to be related to golden proportions apparent in the ideal human face. The aim of the study was to analyse the putative relation between facial aesthetics and golden proportions in Caucasian adolescents.
Methods: 76 adult laypeople evaluated sets of photographs of 64 adolescents on a VAS from 0 to 100. The facial aesthetic value of each individual was calculated as a mean VAS score. Three observers recorded the position of 13 facial landmarks included in nineteen putative golden proportions, based on the golden proportions as defined by Ricketts. The proportions were calculated, as well as each proportion's deviation from the golden target (1.618). This deviation was then related to the VAS scores.
Results: Only four of the 19 proportions had a significant negative correlation with the VAS scores, indicating that beautiful faces showed less deviation from the golden standard than less beautiful faces. Together, these variables explained only 16% of the variance.
Conclusions: Few golden proportions have a significant relation with facial aesthetics in adolescents. The explained variance of these variables is too small to be of clinical importance.

6.1 Introduction

Many guidelines, norms and standards have been proposed to describe the ideal proportions in the human face, and for a long time, golden proportions have supposedly been apparent in the ideal human face.[1]

The golden proportion has been described in a geometrical way in the 4th century BC by Euclid as the unique division of a line (AB) into two parts (AC and CB) in such a way that

$$AB : AC = AC : CB.$$

Although Euclid is the oldest known written source to describe the construction of this golden proportion, the proportion itself was probably already known by the ancient Egyptians, since this ratio might be recognized in the large Egyptian pyramids from the 3rd millennium BC. A more accurate mathematical approach came from Fibonnacci in the 12th century AD, in which the golden proportion was defined as Phi, and was found to be equal to 1.618. Although questioned by some authors,[2] the golden proportion is often associated with aesthetics and harmony in a wide variety of fields such as architecture, sculpture, music, poetry, the morphology of flowers, sea shells, mammals, and also in the human face.

In orthodontics, Ricketts[3,4] was the first to claim that the analysis of a physical beautiful face should be approached on a mathematical basis, and he advocated the use of golden proportions in that respect. He observed dozens of photographs of magazine models in order to select pairs of distances representing golden proportions in those beautiful faces. On this basis he performed a small study using a selection of ten beautiful faces and defined a number of golden proportions in these faces. Although objections were made against the study design,[5] Ricketts's articles[3,4] appear to be key publications in the orthodontic and oral surgery field when it comes to facial aesthetics.

More recently, Baker and Woods[6] and Shell and Woods[7] were unable to establish significant correlations between changes in golden proportions and changes in aesthetic ratings after orthognathic treatment. While most subjects were considered to be aesthetically improved after treatment, the proportions were equally likely to move away from or toward the golden proportion. They therefore concluded that the

achievement of golden proportions had little or no influence on the overall aesthetic scores. Moss *et al.*,[8] who used 3-D optical surface scanning techniques to analyse facial traits in averaged male and female models, concluded that these facial traits did not meet the golden proportions.

However, since there is a large interest in golden proportions as a measure for facial aesthetics in the general public, and since several authors still consider the golden proportion an important factor in facial aesthetics,[9-11] there is a need for evaluation of the relation between the appreciation of facial aesthetics and the presence of golden proportions. Up to now an analysis of the relation between facial aesthetics as perceived by a panel of judges and the presence of golden proportions had never been performed in adolescents.

The present study analyzed the putative relation between appreciated facial aesthetics and the presence of golden proportions in the faces of a group of Caucasian adolescents. The hypothesis to be tested was that the more aesthetic a face was judged by the panel, the less the putative golden proportions would differ from the real golden value (1.618).

6.2 Materials and methods

6.2.1 Material selection

Pre-treatment sets of three photographs (one frontal, one three-quarter smiling, and one lateral) of healthy adolescents were selected from the 1990-2000 files of the Department of Orthodontics and Oral Biology of the Radboud University Nijmegen Medical Centre, The Netherlands. The inclusion criteria were: age between 10 and 16, Caucasian background, not wearing glasses, and no dental or facial trauma, nor any known congenital defects. From this group, sets of photographs of 64 individuals were selected, using randomization in strata according to Angle Class and gender. The Angle Classes were defined as follows: Angle Class I: neutro-occlusion and neutro-relation of the jaws; Class II division 1: disto-occlusion and disto-relation of the jaws with proclined upper incisors; Class II division 2: disto-occlusion and disto-relation of the jaws

with retroclined upper incisors; and Class III: mesio-occlusion and mesio-relation of the jaws. The stratification aimed at about 8 boys and 8 girls for each of the four Angle Classes, in order to obtain a wide range of dental/skeletal variation.

6.2.2 Evaluation of facial aesthetics

A panel of 76 adult laypeople with relatively high socio-economic backgrounds evaluated the sets of photographs on a VAS (visual analogue scale) from 0 (very unattractive) to 100 (very attractive). The sets of photographs were placed in random order in a slide show and each set of photographs was shown for 15 seconds on a wall screen. Scores were given in relation to a reference set of photographs with a known score, as described by Kiekens *et al.*[12] The scores of two panel members were excluded because of missing data. Statistical analysis of the VAS scores was performed on the ratings of the panel of the remaining 74 individuals.

From the scores of all panel members, the final facial aesthetic score for an individual was determined as the mean of all VAS scores given for that individual. This method has shown to yield reproducible results.[12]

6.2.3 Putative golden proportions

Putative golden proportions that can be identified on frontal photographs were taken from Ricketts,[3,4] Baker and Woods,[6] and Mack.[13] In total 19 proportions were selected that might be golden in the ideal face (Figure 6.1 A, B, C). The photographs were digitized at 500 x 751 pixels and the pertaining 13 landmarks were identified on a screen by three independent observers using the Sigma Scan software (Jandel Scientific, San Rafael, CA, USA).

Data quality control of the landmark measurements included the elimination of outliers. To that end, the measurement variance of a specific point was calculated as the mean squared distance of the mean point between the three observations. The measurement error of a landmark was defined as the square root of the median measurement variance over all 64 photographic sets. After assessment of the measurement error of the landmarks, outliers were defined as individual

Figure 6.1 A B C *Schematic drawings illustrating the putative golden proportions.*

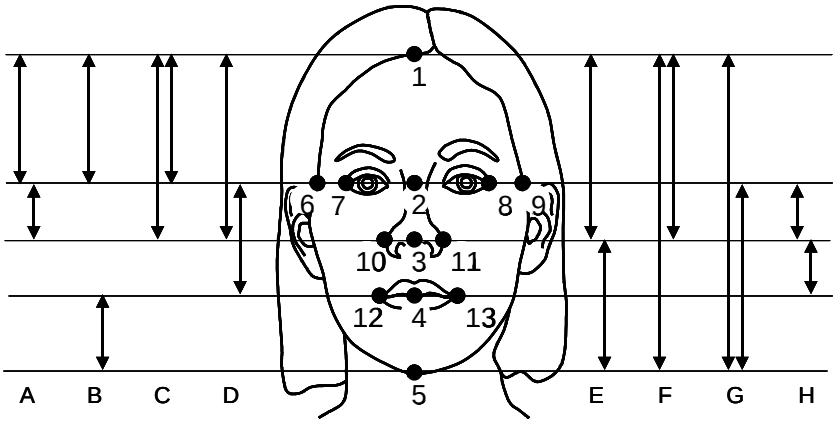

Figure 6.1 A

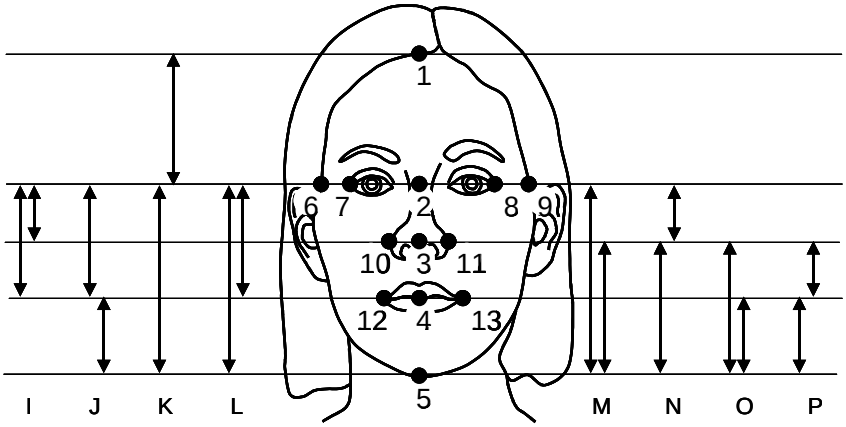

Figure 6.1 B

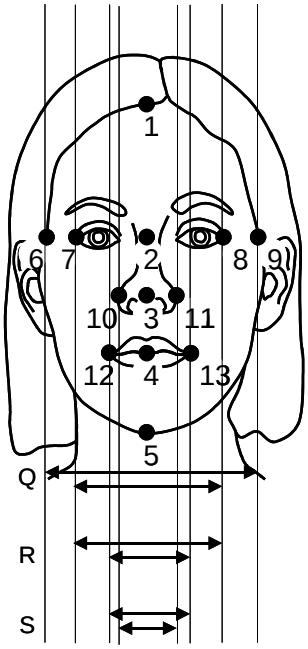

Figure 6.1 C

points with a measurement error larger than 3 times the measurement error in the landmark. In total 0.7% of all measurements appeared to be outliers. They were therefore excluded from further analysis.

6.2.4 The relation between putative golden proportions and facial aesthetics

For each set of photographs, the accepted measurements were used to calculate the ratios as presented in Table 6.1. The z-score of the deviation of an individual ratio (r) from the golden standard (φ) was calculated as

$$z = [\text{individual } (r - \varphi) - \text{mean } (r - \varphi)]/SD$$

(SD = standard deviation of the individual ratio). For further analysis the z-scores were dichotomized (Dz = dichotomized z-scores) as follows:

$$Dz = 0 \text{ if } -0.5 \leq z \leq +0.5 \text{ and}$$

$$Dz = 1 \text{ if } z < -0.5 \text{ or } z > +0.5.$$

This dichotomization was performed in order to reduce the effect of outlying individual proportions and to classify the proportions in only two groups. Within a range of 1 standard deviation (SD) of the z-score ($-0.5 \leq z \leq +0.5$), the ratio was supposed to be close to the golden standard [mean $(r - \varphi)$]. Outside this area ($z < -0.5$ or $z > +0.5$), the ratio was supposed to be away from the golden standard. All individual Dz-scores for each ratio were used as input for a subsequent correlation analysis with the VAS scores. A negative correlation means that the VAS scores in the deviant group (Dz = 1) are lower than the VAS scores in the other group (Dz = 0). A positive correlation points in the other direction.

6.3 Results

The mean VAS score for the photographs of the boys was 55.3 ± 8.9, and for the girls 52.6 ± 9.5. The range of all VAS scores was 31.0 – 70.8.

The measurements of the landmarks that were included in the calculation of the putative golden proportions showed median measurement errors ranging from 2.2 to 9.9 pixels. The largest measurement error was found for point 1, which is point trichion (hair

line at the mid-sagittal plane). The range of the median errors of the remaining landmarks was 2.2 to 5.7.

Table 6.1 *Mean, standard deviation (SD), minimum (Min) and maximum (Max) of the absolute value of each ratio and the correlation coefficient (CC) between the dichotomized z-scores (Dz) and the VAS scores with P-values (* = significant) for each of the 19 putative golden proportions (A-S).*

	Ratio				**Dz ←→ VAS**	
Code	Mean	SD	Min	Max	CC	*P*-value
A	1.805	0.219	0.848	2.577	0.11	0.40
B	1.670	0.212	1.141	2.144	-0.05	0.68
C	1.563	0.092	1.388	2.151	0.07	0.61
D	1.641	0.100	1.414	1.988	0.21	0.09
E	1.573	0.183	1.209	2.436	0.05	0.67
F	1.641	0.076	1.305	1.825	< 0.01	1.00
G	1.645	0.064	1.517	1.859	0.06	0.61
H	1.396	0.138	1.117	1.832	0.11	0.39
I	1.717	0.092	1.223	1.895	0.16	0.22
J	**1.578**	**0.147**	**1.200**	**1.883**	**-0.27**	**0.03***
K	1.561	0.153	1.163	1.931	0.04	0.75
L	**1.639**	**0.062**	**1.531**	**1.835**	**-0.36**	**< 0.01***
M	1.556	0.064	1.435	1.828	0.02	0.87
N	1.810	0.230	0.706	2.299	0.03	0.79
O	**1.654**	**0.071**	**1.326**	**1.783**	**-0.32**	**0.01***
P	**1.518**	**0.150**	**1.067**	**2.037**	**-0.30**	**0.02***
Q	1.526	0.065	1.368	1.724	-0.03	0.84
R	1.845	0.171	1.475	2.232	-0.05	0.69
S	1.366	0.117	1.039	1.688	0.08	0.51

The mean, standard deviation (SD), and minimum and maximum of the absolute value of each putative golden proportion (r) are given in Table 6.1. The means for the putative golden proportions (r) ranged from 1.366 to 1.845. The standard deviation (SD) varied from 0.062 to 0.230.
The correlation coefficients between the dichotomized z-scores and the VAS scores with their *P*-values are also given in Table 6.1. The absolute

value of the correlation coefficients ranged from < 0.01 to 0.36, and the *P*-values ranged from < 0.01 to 1.00. Out of the 19 putative golden proportions only four showed a significant correlation with the VAS scores, namely J (r = –0.27, P = 0.03), L (r = –0.36, P < 0.01), O (r = –0.32, P = 0.01), and P (r = –0.30, P = 0.02). These correlation coefficients were all negative, which means that the deviant group (Dz = 1) had lower aesthetic scores than the other group (Dz = 0). However, the explained variance of each of these proportions was low: r^2 (J) = 0.07; r^2 (L) = 0.13; r^2 (O) = 0.10; r^2 (P) = 0.09. When the four significant proportions were summed (as Dz04), the correlation coefficient between Dz04 and the VAS scores was –0.40 (P < 0.01) and the explained variance increased to 0.16.

6.4 Discussion

The distances in this study were calculated directly between the landmarks. No reference axes, no projections, perpendiculars, nor tangent lines were used. These restrictions were followed in order to avoid projection errors and to make the measurement technique more simple and applicable in clinical practice.

Unlike in Ricketts's approach,[3,4] it was considered important that not only beautiful faces were used. We therefore used a random selection of untreated adolescents who visited our clinic. The reference level of the golden standard was defined as the group mean of r minus φ. Based on the work of Ricketts,[3,4] Baker and Woods,[6] and Mack,[13] nineteen putative golden proportions were identified, and related to the outcomes of the panel judgments. The dichotomized z-scores of twelve of these proportions showed a positive correlation coefficient, indicating that the deviant group had higher VAS scores than the other group. It should be noted, however, that none of these correlations were significant (0.09 < P < 1.00). The dichotomized z-scores of the other seven proportions pointed into the other direction, but only four showed a significant negative correlation with the VAS scores. The explained variance of these four dichotomized z-scores was low (0.07 ≤ r^2 < 0.13). The sum

score of the four significant dichotomized z-scores (Dz04) resulted in an increase of the explained variance to 0.16. Higher Dz04 scores gave lower VAS scores, (and vice versa). This means that more beautiful faces show less deviation from these four golden proportions than less beautiful faces. However, the explained variance is low, indicating that the perception of facial aesthetics depends very little on the presence of golden proportions in the adolescent face.

6.5 Conclusion

Few golden proportions have a significant relation with facial aesthetics in adolescents. Moreover, the explained variance of the significant variables is too small to be of clinical importance.

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Chapter 7

Facial aesthetics in adolescents and its relation to 'ideal' ratios and angles

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Summary

Introduction: Many guidelines, norms, and ideal ratios and angles for attractive faces have been proposed in the literature. The aim of this study was to test the hypothesis that facial attractiveness in adolescents is related to ideal angles and ratios, as indicated in the literature.
Methods: Seventy-six laypeople viewed sets of photographs of 64 adolescents and rated them on a visual analogue scale (VAS) from 0 to 100. The facial aesthetic value of each individual was calculated as a mean VAS score. Three observers recorded the positions of 61 landmarks, and 45 were found to have acceptable reproducibility. Based on these 45 landmarks, 27 ideal ratios on frontal photographs and 26 ideal angles on lateral photographs were identified in the literature. These ratios and angles were calculated on each photograph, and their deviation from the ideal targets in the literature were determined. Each deviation was related to the VAS score.
Results: Two ratios and 3 angles had a significant negative correlation with the VAS scores, indicating that beautiful faces have less deviation from the ideal target than less beautiful faces. Together, these variables explained 28.7% of the variance.
Conclusions: Few ‘ideal’ ratios and angles have a significant relationship with facial aesthetics in adolescents.

7.1 Introduction

Soft-tissue facial analyses can be made on lateral cephalograms and photographs, by anthropometry (measurements directly on the face), or with 3-dimensional imaging techniques. Many guidelines, norms, and ideal ratios and angles dealing with attractive faces, have been proposed in the literature, mainly based on 2-dimensional measurements. Few investigators, however, have shown a scientific basis for their criteria; in general, the choice of the criteria themselves and their assumed optimal value are arbitrary. Most 'ideal' norms are given for adults and especially for women. They are often based on beautiful or idealized faces, or on author's preferences,[1-15] whereas others are based on average faces.[16-21] Average values have been considered 'ideal', assuming that average faces are attractive,[22] and that average facial proportions could provide a basis for quantitative assessment of facial aesthetics.[23] Norms for facial proportions and angles for adolescents are rare in the literature. Farkas and Munro[16] stated that average differences in facial proportions between both sexes from 6 to 18 years are relatively small. Halazonetis[24] found only minor differences in the average facial shapes of boys and girls between 7 and 17 years of age. Although some facial proportions and angles might be different for adults and children[25] and for males and females,[14] most orthodontists use the 'ideal' norms for all patients, irrespective of their age or sex.

Our aim in this study was to test the hypothesis that facial attractiveness in adolescents is related to 'ideal' ratios and angles, as indicated in literature.

7.2 Materials and methods

7.2.1 Material selection

Pretreatment sets of three photographs (frontal, ¾ smiling, and lateral) of adolescents were collected from the files of the Department of Orthodontics and Oral Biology, Radboud University Nijmegen Medical Centre, The Netherlands, from 1990 to 2000. The inclusion criteria were age between 10 and 16 years at start of treatment, Caucasian background, not wearing glasses, no dental or facial trauma, and no congenital defects. From this group, sets of photographs of 64 adolescents were selected, using randomization in strata according to Angle Class and sex. The Angle Classes were defined as follows: Angle Class I: neutro-occlusion and neutro-relationship of the jaws; Class II division 1: disto-occlusion and disto-relationship of the jaws with proclined maxillary incisors; Class II division 2: disto-occlusion and disto-relationship of the jaws with retroclined maxillary incisors; and Class III: mesio-occlusion and mesio-relationship of the jaws. The stratification aimed for about eight boys and eight girls for each of the four Angle Classes to obtain a wide range of dental and skeletal variations.

7.2.2 Evaluation of facial aesthetics

A panel of 76 lay adults with relatively high socio-economic backgrounds evaluated the sets of photographs on a visual analogue scale (VAS) from 0 (very unattractive) to 100 (very attractive). The sets of photographs were placed in random order in a slide show, and each set was shown for 15 seconds on a wall screen. Scores were given in relation to a reference set of photographs with a known score, as described by Kiekens *et al.*[26] The scores of two panel members were excluded because of missing data. Statistical analyses of the VAS scores were performed on the ratings of the panel of the remaining 74 persons.

From the scores of all panel members, the final facial aesthetic score for a subject was determined as the mean of all VAS scores given for him or her. This method has shown to yield reproducible results.[26]

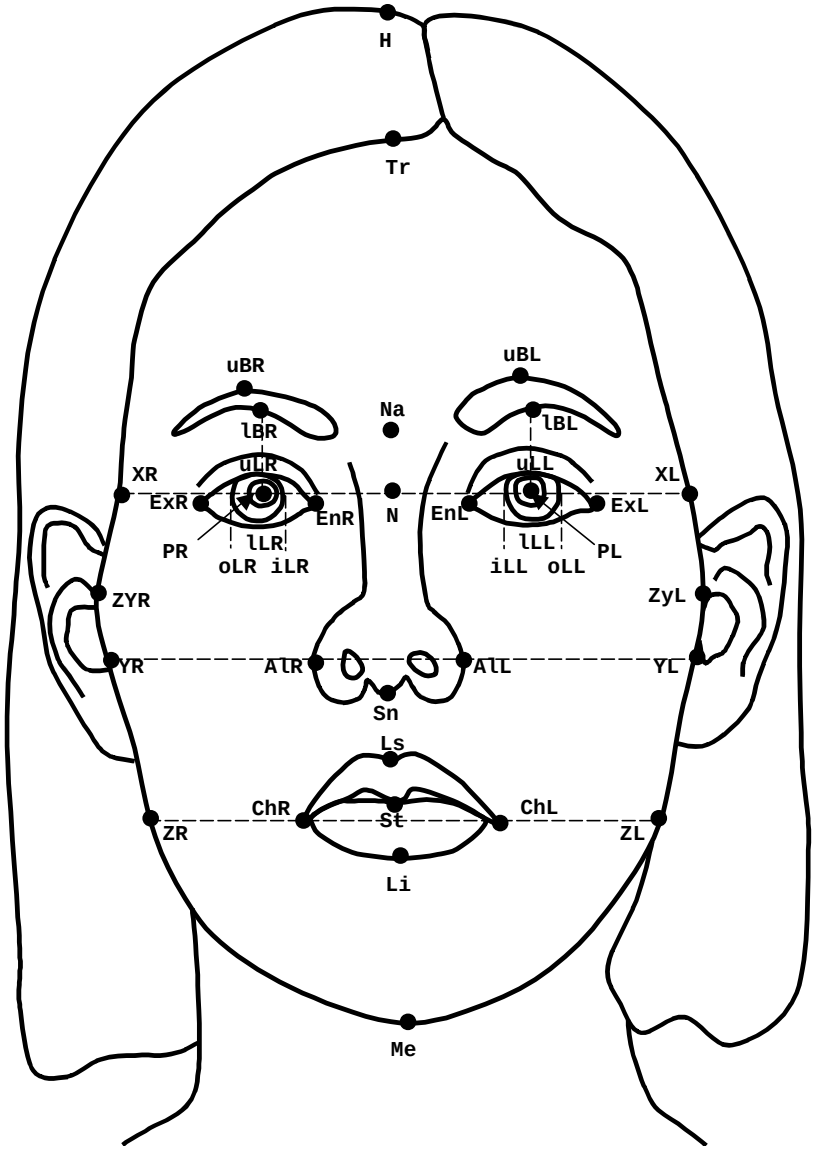


Figure 7.1 *Landmarks on the frontal photograph. Landmarks in 'italics' were rejected.*

H *= estimated middle of the hair top,* **Tr** = Trichion, ***uBR*** *= upper border of the eyebrow on the right side,* ***uBL*** *= upper border of the eyebrow on the left side,* **lBR** = lower border of the eyebrow on the right side, **lBL** = lower border of the eyebrow on the left side, ***Na*** *= skin Nasion,* **N** = skin Nasion at bipupil line (constructed point), **ExR** = Exocanthion on the right side, **ExL** = Exocanthion on the left side, **EnR** = Endocanthion on the right side, **EnL** = Endocanthion on the left side, **uLR** = upper Limbus on the right side, **uLL** = upper Limbus on the left side, **lLR** = lower Limbus on the right side, **lLL** = lower Limbus on the left side, ***oLR*** *= outer Limbus on the right side,* ***oLL*** *= outer Limbus on the left side,* ***iLR*** *= inner Limbus on the right side,* ***iLL*** *= inner Limbus on the left side,* **PR** = middle of the Pupil on the right side, **PL** = middle of the Pupil on the left side, **AlR** = Alare on the right side, **AlL** = Alare on the left side, **Sn** = Subnasale, **St** = Stomion, **ChR** = Cheilion on the right side, **ChL** = Cheilion on the left side, **Ls** = labrale superior, **Li** = labrale inferior, **Me** = Menton, ***ZyR*** *= Zygion on the right side,* ***ZyL*** *= Zygion on the left side,* **XR-XL** = face width at Bipupil line (XR and XL = constructed points), **YR-YL** = face width at Alare (YR and YL = constructed points), **ZR-ZL** = face width at Stomion (ZR and ZL = constructed points).

7.2.3 Search for reliable landmarks

All frontal and lateral photographs were digitized at 500 x 751 pixels. Sixty-one landmarks, frequently found in the literature, pertaining to 'ideal' ratios and angles were identified on a screen by three independent observers using 'Sigma Scan' (Jandel Scientific, San Rafael, CA, USA). On the frontal photographs, 39 landmarks and, on the lateral photographs, 22 landmarks were selected (Figures 7.1 and 7.2). Because the accuracy of the determination of soft tissue landmarks is variable,[4] a data quality control of the landmark measurements was performed, including the elimination of outliers. To that end, the measurement variance of a specific point on a photograph was calculated as the mean squared distance of the mean point between the three observations. The measurement error of each landmark was defined as the square root of the median measurement variance of the landmark over all 64 photographic sets. After assessment of the measurement error of the landmarks, outliers were defined as individual points with a measurement error larger than 3 times the measurement error in the landmark. In total 1.3% (150) of all measurements (64 patients x 61 landmarks x 3 observers = 11.712) appeared to be outliers. They were excluded from further analysis. After the elimination of outliers, the measurements of the 61 landmarks showed median errors ranging from 1.2 to 32.5 pixels, indicating that the quality of the landmarks was diverse. As an inclusion criterion for a landmark, a median measurement error equal to or less than 5 pixels was taken. All landmarks with low reproducibility were excluded, except two landmarks on the frontal and two landmarks on the lateral photographs. These landmarks were included, because they are often used in the literature and could not be replaced by more accurate landmarks. On the frontal photographs, these landmarks were XL and Tr with median measurement errors of 5.7 and 9.9 pixels, respectively; on the lateral photographs, these landmarks were G and Gn with median measurement errors of 12.6 and 15.1, respectively. In total, 45 landmarks with acceptable reproducibility, 29 on the frontal and 16 on the lateral photographs, were included in the analysis (Figure 7.1 and 7.2).

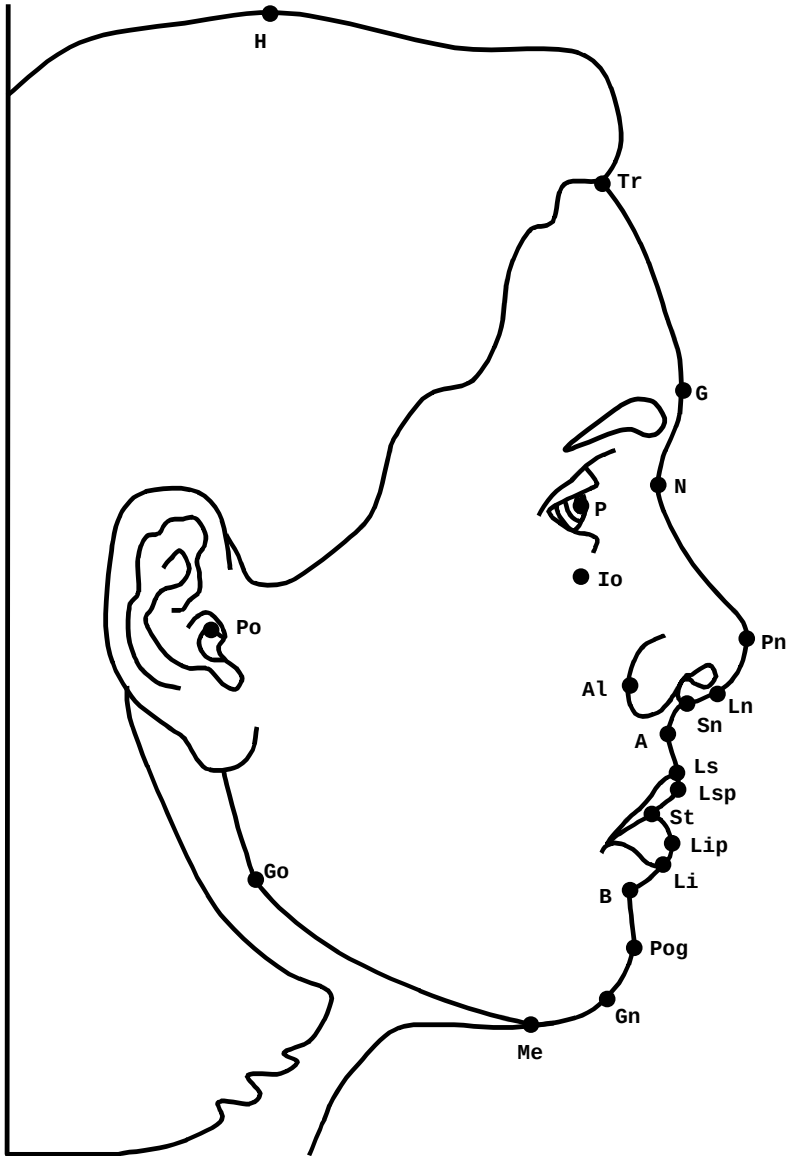


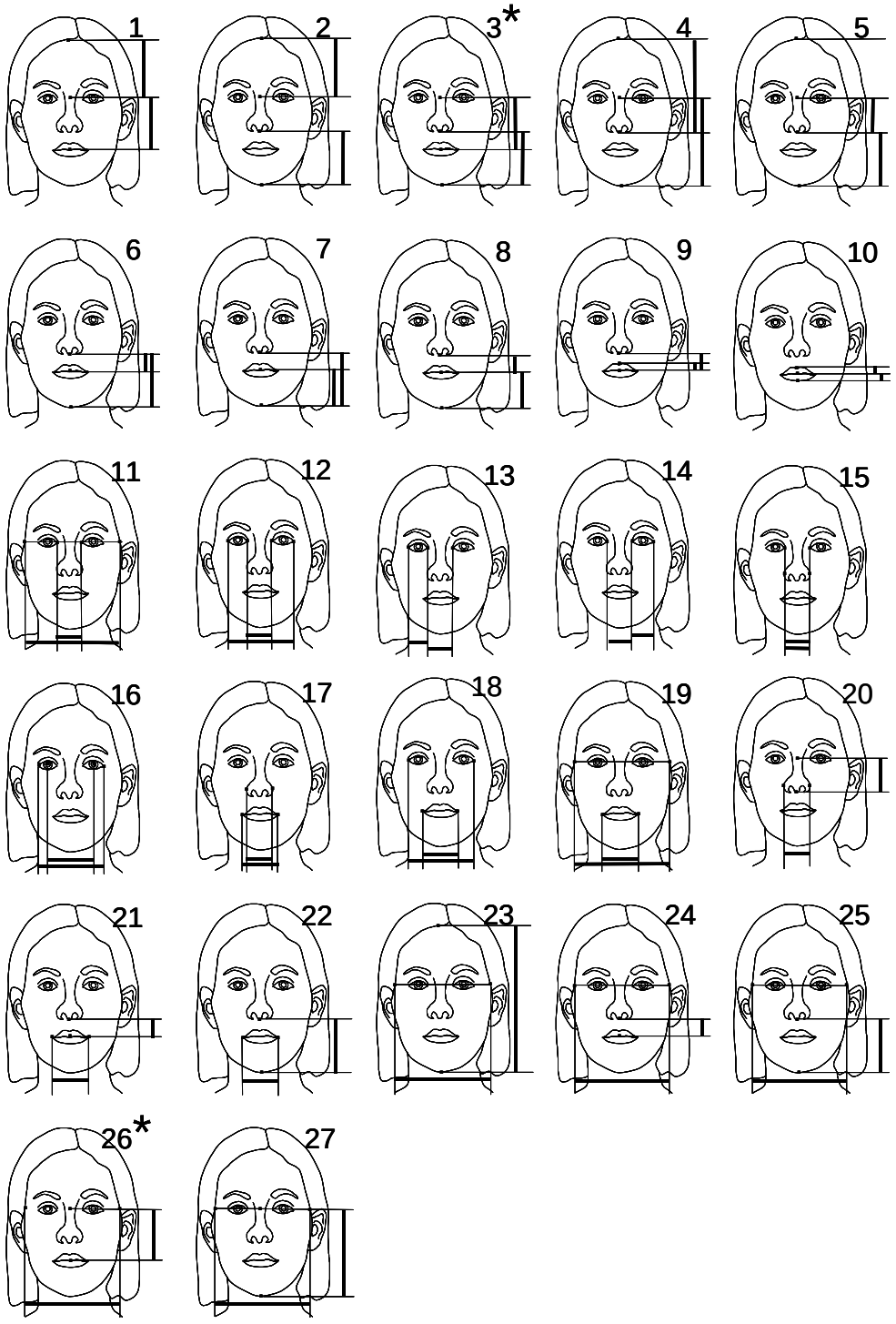
Figure 7.2 *Landmarks on the lateral photograph. Landmarks in 'italics' were rejected.*

H *= Hair top,* ***Tr*** *= Trichion,* **G** = Glabella, **N** = Nasion, **P** = Pupil, ***Io*** *= Infraorbitale,* **Pn** = Pronasale, **Al** = Alare, ***Ln*** *= Lowest nose point,* **Sn** = Subnasale, **A** = soft-tissue point A, **Ls** = Labrale superior, **Li** = Labrale inferior, **St** = Stomion, **Lsp** = most protruded point of upper lip, **Lip** = most protruded point of lower lip, **B** = soft tissue point B, **Pog** = Pogonion, **Gn** = Gnathion, ***Me*** *= Menton,* ***Go*** *= Gonion.*

7.2.4 'Ideal' ratios and 'ideal' angles

'Ideal' ratios on the frontal photographs and 'ideal' angles on the lateral photographs, dealing with the accepted landmarks, were selected from the literature.[1-21] In some ratios and one angle, the nonreproducible

landmarks were replaced by more accurate landmarks. By this procedure, Na was replaced by N, ZyR and ZyL by XR and XL, and Me by Gn.



** = Significant (P < 0.05) correlation with the dichotomized z-scores.*

Figure 7.3 *Twenty-seven 'ideal' ratios on a frontal photograph, based on the accepted landmarks in the literature.*

Because ‘ideal’ ratios and angles for adolescents were seldom available in the literature, proposed ideals for young adults were used. If separate ideals were given for both sexes, their mean value was used to test the hypothesis that ‘ideal’ ratios and angles as proposed in the literature, can be used for all adolescents, aged 10-16 years, irrespective of age or sex. In total, 27 ratios on the frontal photographs and 26 angles on the lateral photographs were selected (Figures 7.3 and 7.4). Descriptions of the ratios and angles, with the ‘ideal’ targets and their authors, are given in Tables 7.1 and 7.2.

7.2.5 Relation between facial aesthetics and ‘ideal’ ratios and angles

For each set of photographs, the accepted measurements were used to calculate the ratios and angles as presented in Tables 7.1 and 7.2. The z-score of the deviation of an individual variable (v) from its ‘ideal’ target (t) was calculated as

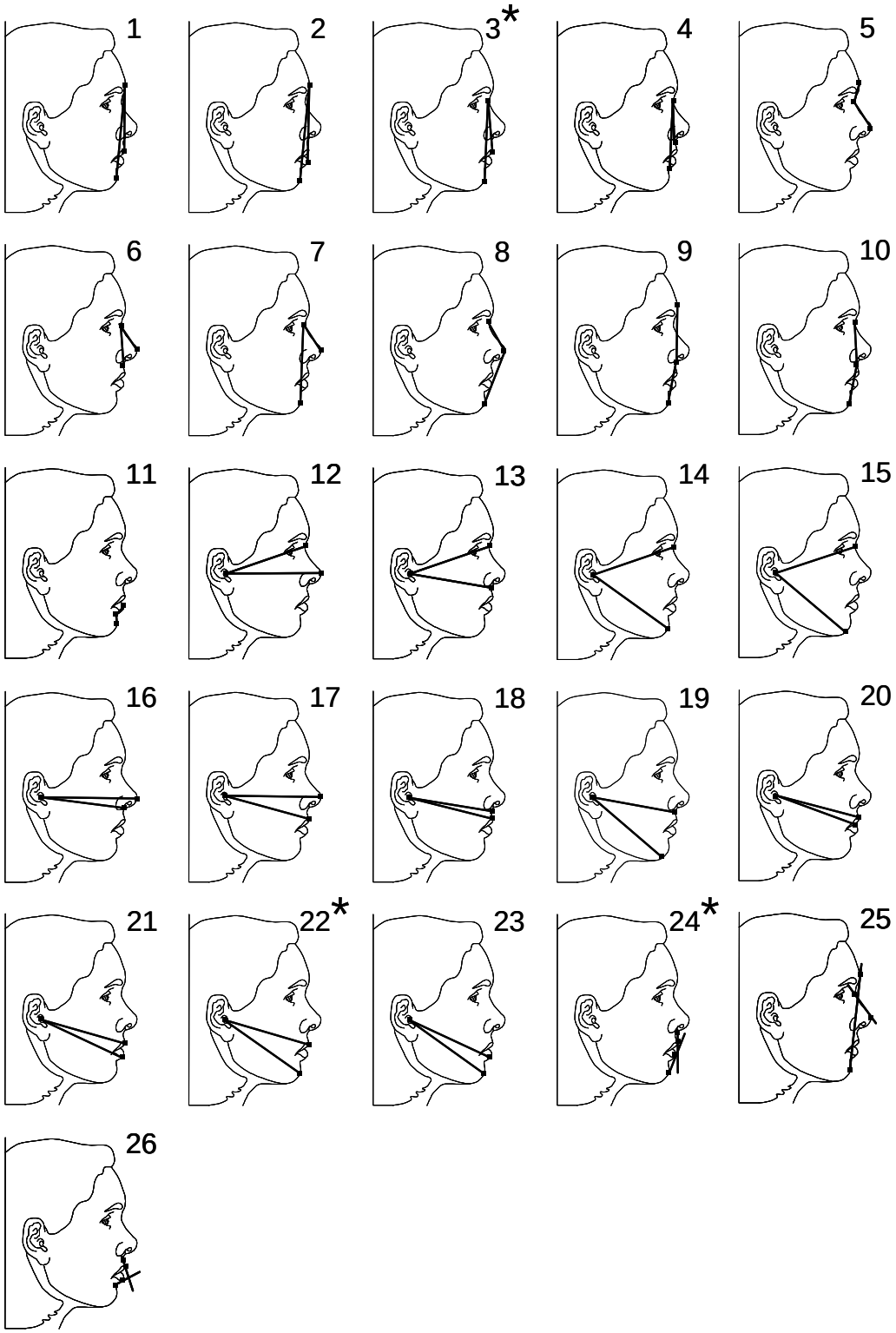
$$z = [\text{individual } (v - t) - \text{mean } (v - t)]/SD$$

(with SD as the standard deviation of the individual variable).

For further analysis the z-scores were dichotomized (Dz = dichotomized z-scores) as follows:

$$Dz = 0 \text{ if } -0.5 \leq z \leq +0.5 \text{ and}$$
$$Dz = 1 \text{ if } z < -0.5 \text{ or } z > +0.5.$$

This dichotomization was performed to reduce the effect of outlying individual variables and to classify these variables in only two groups. Within a range of 1 SD of the z-score ($-0.5 \leq z \leq +0.5$), the variable was supposed to be close to the ‘ideal’ target; outside this area ($z < -0.5$ or $z > +0.5$), the variable was supposed to be different from the ‘ideal’ target. All individual Dz-scores for each variable were used as input for subsequent correlation analysis with the VAS scores on facial aesthetics. A negative correlation means that the VAS scores in the deviant group (Dz = 1) were lower than the VAS scores in the other group (Dz = 0). A positive correlation points in the other direction. Subsequently, multivariate regression was performed to ascertain the combined effect of the significant dichotomized z-values of the angle and ratio measurements on the dependent variable of the VAS score.



** = Significant (P < 0.05) correlation with the dichotomized z-scores.*

Figure 7.4 *Twenty-six 'ideal' angles on a lateral photograph based on the accepted landmarks in the literature.*

Table 7.1 *Description, target, author, and sample described in the literature, correlation coefficient (CC) between the dichotomized z-scores (Dz) of the deviation of the ratio from the target, and the VAS scores with P-values for the 27 investigated ratios on frontal photographs.*

Variables	Description	Target	Author	Target base	Dz / VAS	
					CC	*P*
Ratio 1	Tr-N/N-St	1	Ricketts[1,2]	10 Selected adult female fashion models Age unknown	0.13	0.30
Ratio 2	Tr-N/Sn-Me	1	Ricketts[1,2] Al-Al line replaced by SN		-0.10	0.42
Ratio 3*	N-St/Sn-Me	1			-0.32	0.01*
Ratio 4	Tr-Sn/N-Me	1			-0.04	0.77
Ratio 5	N-Sn/Sn-Me	0.754	Powell and Humphreys[3] McNamara et al.[4] Na replaced by N	Idealized males and females	-0.16	0.20
Ratio 6	Sn-St/Sn-Me	0.333	Powell and Humphreys[3] Proffit et al.[5]	Idealized males and females	0.04	0.78
Ratio 7	St-Me/Sn-Me	0.667	Farkas[16] Munro	654 males and 658 females 6-18 y Mean 10-16 y	0.04	0.78
Ratio 8	Sn-St/St-Me	0.5	Arnett and Bergman[6,7]	Authors' normative value for facial beauty	0.04	0.78
Ratio 9	Ls-St/Sn-St	0.36	Farkas et al.[17]	50 males and 39 females Age 18-25 y	0.06	0.64
Ratio 10	Ls-St/St-Li	0.88			-0.02	0.88
Ratio 11	EnR-EnL/XR-XL	0.2	El-Mangoury et al.[8]	Authors' guide-lines for good facial aesthetics	-0.10	0.44
Ratio 12	EnR-EnL/ExR-ExL	0.333	Powell and Humphreys[3] McNamara et al.[4] Proffit et al.[5] El-Mangoury et al.[8]	Idealized males and females	-0.02	0.85
Ratio 13	ExR-EnR/EnR-EnL	1			0.03	0.79
Ratio 14	EnL-ExL/EnR-EnL	1			0.02	0.86
Ratio 15	EnR-EnL/AlR-AlL	1	McNamara et al.[4] Proffit et al.[5]		-0.20	0.11
Ratio 16	PR-PL/ExR-ExL	0.7	Koury and Epker[18] ZyR-ZyL replaced by XR-XL Na replaced by N	Data from Farkas mean females Age 18-25 y	0.06	0.64
Ratio 17	AlR-AlL/ChR-ChL	0.625			0.12	0.36
Ratio 18	ChR-ChL/ ExR-ExL	0.6			-0.10	0.44
Ratio 19	ChR-ChL/XR-XL	0.4			0.03	0.84
Ratio 20	AlR-AlL/N-Sn	0.625			0.22	0.08
Ratio 21	Sn-St/ChR-ChL	0.4			0.08	0.55
Ratio 22	Sn-Me/ChR-ChL	1.33	Koury and Epker[18]	Data from Farkas mean males/females Age 18-25 y	-0.02	0.88
Ratio 23	XR-XL/Tr-Me	0.783	Jacobson[9] ZyR-ZyL replaced by XR-XL Na replaced by N	Authors' opinion of balanced facial aesthetics mean male/female mesoprosopic	-0.01	0.96
Ratio 24	Sn-St/XR-XL	0.225			0.01	0.95
Ratio 25	Sn-Me/XR-XL	0.53			-0.21	0.09
Ratio 26*	N-St/XR-XL	0.535			-0.29	0.02*
Ratio 27	N-ME/XR-XL	0.86			0.12	0.33

** Significant at P < 0.05 level.*

Table 7.2 *Description, target, author and sample described in the literature, correlation coefficient (CC) between the dichotomized z-scores (Dz) of the deviation of the angle, and the VAS scores with P-values for the 26 investigated angles on lateral photographs.*

Variables	Description	Target	Author	Target base	Dz / VAS	
					CC	*P*
Angle 1	Lsp-G-Pog	6.3°	Nguyen and Turley[10] Auger and Turley[11]	43 male/25 female fashion models (1980-1995) Estimated age 18-35 y	-0.02	0.85
Angle 2	Lip-G-Pog	3.3°			-0.10	0.44
Angle 3*	Lsp-N-Pog	5.9°	Peck and Peck[12]	52 aesthetically pleasing faces (49 females/3 males) Mean age 21.2 y	-0.29	0.02*
Angle 4	A-N-B	7.1°	Cox and van der Linden[13]	Best facial harmony 18 males/18 females (from a group of 87 males/87 females) Age 18-20 y	0.01	0.91
Angle 5	G-N-Pn	140.3°	Fernandez-Riviero et al.[19]	50 males/162 females Age 18-20 y	-0.16	0.21
Angle 6	Pn-N-Sn	22.5°	Lines et al.[14]	Preferred composite male/female silhouettes of profiles	0.15	0.24
Angle 7	Pn-N-Pog	27.5°			-0.13	0.30
Angle 8	N-Pn-Pog	129.5°	Cox and van der Linden[13]	Best facial harmony 18 males/18 females from a group of 87 males/87 females) Age 18-20 y	-0.04	0.76
Angle 9	G-Sn-Pog	170.0°	Nguyen and Turley[10] Auger and Turley[11]	43 male/25 female fashion models (1980-1995) Estimated age 18-35 y	0.02	0.87
Angle 10	N-Sn-Pog	163.0°	Cox and van der Linden[13]	Best facial harmony 18 males/18 females (from a group of 87 males/87 females) Age 18-20 y	-0.12	0.34
Angle 11	Lip-B-Pog	125.4°	Lines et al.[14]	Preferred composite male/female silhouettes of profiles	-0.06	0.62
Angle 12	N-Po-Pn	23.6°	Peck and Peck[12]	52 aesthetically pleasing faces (49 females/3 males) Mean age 21.2 y	-0.19	0.13
Angle 13	N-Po-Sn	28.5°	Fernandez-Riviero et al.[19]	50 males/162 females Age 18-20 y	-0.14	0.29
Angle 14	N-Po-Pog	54.4°	Peck and Peck[12]	52 aesthetically pleasing faces (49 females/3 males) Mean age 21.2 y	-0.04	0.74

Variables	Description	Target	Author	Target base	Dz / VAS	
					CC	*P*
Angle 15	N-Po-Gn	57.0°	Hautvast[20]	1110 children (11-14 y) At 13 y	-0.02	0.89
Angle 16	Pn-Po-Sn	7.0°			0.09	0.46
Angle 17	Pn-Po-Ls	14.5°	Nanda et al.[15]	25 male/25 female aesthetically pleasing balanced profiles Age 21-36 y	0.08	0.55
Angle 18	Sn-Po-Ls	7.0°	Hautvast[20]	1110 children (11-14 y) At 13 y	0.19	0.14
Angle 19	Sn-Po-Gn	36.5°	Fernandez-Riviero et al.[19] Me replaced by Gn	50 males/162 females Age 18-20 y	-0.16	0.19
Angle 20	Ls-Po-St	2.8°	Nanda et al.[15]	25 male/25 female aesthetically pleasing balanced profiles Age 21-36 y	-0.03	0.81
Angle 21	Ls-Po-Li	7.1°			-0.01	0.96
Angle 22*	Ls-Po-Pog	17.1°	Peck and peck[12]	52 aesthetically pleasing faces (49 females/3 males) Mean age 21.2 y	-0.28	0.02*
Angle 23	Li-Po-Pog	12.5°	Nanda et al[15]	25 male/25 female aesthetically pleasing balanced profiles	-0.14	0.27
Angle 24*	Sn-Lsp-/Pog-Lip	157.3°	Ferrario et al.[21]	70 males/71 females Mesocephalic Age 11-13 y	-0.25	0.04*
Angle 25	G-Pog/N-Pn	35.0°	Koury and Epker[18]	Data from Farkas mean females Age 18-25 y	-0.04	0.77
Angle 26	B-Lip/Lsp-A	125.0°	Nguyen and Turley[10] Auger and Turley[11]	43 male/25 female fashion models (1980-1995) Estimated age 18-35 y	-0.01	0.91

** Significant at P < 0.05 level.*

7.3 Results

The mean VAS scores for the photographs were 55.3 ± 8.9 for the boys and 52.6 ± 9.5 for the girls. The range of all VAS scores was 31.0 to 70.8.

The correlation coefficients between the dichotomized z-scores and the VAS scores, with their *P*-values are given in Tables 7.1 and 7.2. Of the 27 investigated ratios, only two were significantly correlated with the

VAS scores, and both had the desired negative sign: ratio 3 (r = –0.32, *P* = 0.01) and ratio 26 (r = –0.29, *P* = 0.02) (Table 7.1, Figure 7.3). When these two variables were combined, the correlation coefficient increased to *r* = 0.41 (*P* < 0.001) with an explained variance of 16.8% (prognostic value). Three of the 26 investigated angles were significantly correlated with the VAS scores, and all three had the desired negative sign: angle 3 (*r* = –0.29, *P* = 0.02), angle 22 (*r* = –0.28, *P* = 0.02), and angle 24 (*r* = –0.25, *P* = 0.04) (Table 7.2, Figure 7.4). When these three variables were combined in the multivariate regression analysis, the correlation coefficient increased to *r* = 0.43 (*P* < 0.001) with an explained variance of 18.5%. When the two significantly correlated ratios and the three significantly correlated angles were combined, the explained variance of this combination of the five variables was 28.7% (*P* = 0.004).

7.4 Discussion

The ratios and the angles in this study were calculated directly between the landmarks. No reference axes, projections, perpendiculars, or tangent lines were used. These restrictions were followed to prevent projection errors and to make the measurement technique simpler and more applicable in clinical practice. Because of these restrictions and the fact that some landmarks with a low reproducibility were excluded, some ratios and angles with their proposed targets described in literature were not tested.

Although a search for reliable landmarks was performed, the authors realize that the error in a given measurement does not depend only on the reproducibility of the landmarks involved. A vertical measurement error in a certain landmark has a greater impact on the measurement of a vertical distance than on a horizontal distance between this landmark and another landmark. The absolute distance between landmarks is also important. The smaller the distance between two landmarks, the more impact an erroneous landmark has on the measurement. It is also true that if the same landmark is involved in the two magnitudes of a ratio, an erroneous measurement of this landmark will have a high impact on the

measurement of this ratio (because the two magnitudes of the ratio can change in a different direction).

Since it was considered important that not only beautiful faces were tested, we used a random selection of untreated adolescents who visited our clinic, representing a broad range of faces with different characteristics.

Professionals show great confidence in the so-called 'ideal' ratios and angles, and use them as guidelines in their treatment plans. However, on the relation of facial features with facial aesthetics in adolescents, little evidence is available. The use of various landmarks and the mixture of ages and sexes might be why so little evidence was found for so-called 'ideal' ratios and angles.

The dichotomized z-scores of only two ratios and three angles showed a negative and significant correlation with the VAS scores, indicating that subjects with values close to the 'ideal' target were judged to be more attractive than the others. The sum score of these five dichotomized z-scores resulted in an explained variance of 28.7%. This is not high, but far higher than the explained variance of 16% in a previous investigation on the relationship between golden proportions and facial aesthetics.[27]

7.5 Conclusion

From the 'ideal' proportions and angles found in the literature, few have a significant relationship with facial aesthetics in adolescents. Combining these significant ratios and angles yields an explained variance of 28.7%.

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Chapter 8

General discussion

8.1 Introduction

Although aesthetic improvement is the most frequently reported reason for seeking orthodontic treatment,[1-3] and although orthodontic treatment in Europe is most frequently performed during adolescence, only little research has been performed on the evaluation of facial aesthetics in adolescents and on changes in facial aesthetics brought about by orthodontic treatment and growth. Yet, sound knowledge about these topics is important for a proper evaluation of the extent to which orthodontists and orthodontic treatment modalities can meet the expectations of the patients and their parents.

In this chapter the study design as well as the results are discussed, and indications for future research are given.

8.2 Study design

8.2.1 The subjects

The subjects in this study were Caucasian adolescent patients treated at the Department of Orthodontics and Oral Biology of the Radboud University Nijmegen Medical Centre, The Netherlands. For most studies in this thesis a group of 64 adolescents subjects was used, with an almost equal distribution over both genders and the four Angle Classes. This is a strong point of this thesis, as this group shows a wide range of skeletal and dental variation. Samples of ideal faces, or samples in which Angle Class III patients were excluded, have been used in many other studies. Such samples however, have the drawback that they do not incorporate the full extent of facial variability.

8.2.2 Presentation of the subjects

Standardized photographic sets of adolescents showing a frontal, ¾ smiling and a profile view simultaneously were used in this study. Such set of photographs of a patient is a standardized record, normally available in any orthodontic practice. However, although a close relationship was found between judgments of facial aesthetics and colour

photographs,[4] a drawback of these records is that they give only a limited presentation of the face. In future research, it might be considered to use static 3D images and/or dynamic video registration to give a complete visualisation of the face. 3D imaging of the faces and 3D facial morphometry is a rapidly developing technique. It allows the calculation of facial volumes and facial depth, which are difficult or even impossible to obtain with conventional methods.[5] Van der Geld et al.[6] indicated that spontaneous smiling is important in the evaluation of lip-tooth relationships for orthodontic diagnosis. As it is difficult to obtain standardized photographs with a spontaneous smile, they proposed the use of dynamic video records in the orthodontic practice. It might be possible that using 3D imaging or dynamic registration new variables can be identified, which are related to facial aesthetics.

The subjects involved in this study were selected from the 1990-2000 files of the Orthodontic Department. At the time of the evaluation, some photographs were over 10 years old, while others were more recent. This might have been a confounding factor, since fashion and hairstyle, may have an influence on the evaluation of facial aesthetics. To minimize this problem the panel members were instructed to ignore hairstyle and to look at the faces only.

8.2.3 Panel evaluation

The present studies showed that for the comparison of facial aesthetics and for the judgment of changes in facial aesthetics following orthodontic treatment in adolescents panels with consistent characteristics should be used.

The optimal panel size, determined as the smallest panel size that gives reliable results, was found to be 7 to 13 randomly selected panel members, depending on the method used. These findings can be useful in other investigations and in further research on facial aesthetics in general.

We followed the opinion of Bowman and Johnston[7] and Knight and Keith[8] that the opinion of laymen, the end-users of orthodontic treatment is the most valuable in determining facial aesthetics. Therefore, in Chapter 5, 6, and 7 facial characteristics were related to facial aesthetics as evaluated by laymen only. These laymen were adults evaluating facial

aesthetics of adolescents. The reason for this is that parents' motivation has been shown to be the most important factor in initiating orthodontic treatment.[9,10]

The laymen in this investigation had a relatively high socio-economic status and were members or relatives of members of Rotary and Professional Women's Association. Different age groups and a variety of backgrounds and occupations were represented. The panel members also had children or grand children who received orthodontic treatment. In the USA (Florida) Wheeler et al.[11] and in Europe (Wales) Kenealy and Shaw[12] found that there was more demand and uptake of orthodontic treatment in higher socio-economic groups. Therefore, our panel may be representative for that part of the population, mostly dealing with orthodontic treatment.

8.2.4 Measuring instruments

At the start of this investigation, there was no simple measuring instrument for the evaluation of facial aesthetics in adolescence. Visual analogue scales (VAS) are often used,[4,13-16] and the use of reference photographs has been advocated.[17,18] (Peerlings et al 1995; Faure et al 2002). The two reference sets of photographs in our study had a VAS score of 53.1 and 56.1 respectively. These values serve as anchor points for the judgments by all panel members.

In order to help the raters with their scores, tens were marked on the VAS scale. It cannot be assumed that the interval between e.g. 10 and 20 is the same as between e.g. 50 and 60, or that identical scores by different raters, express the same feeling. Different raters also do not interpret the anchor points the same. Phillips et al.[13] considered that by using a VAS scale, the distribution of the ratings might not be the same, some raters use the scale over a larger extend than others (some may neglect certain portions of the scale), therefore they converted the raw scores on the VAS to a ranking scale. This procedure was not performed in the present study, since it was necessary to obtain numeric values to search for correlations between facial aesthetics and objective measures, golden and ideal ratios and angles. Recording the results on the VAS as continuous variables in millimetres, gives more freedom in the statistical analysis.

We also used a 5-point scale with scores varying from –2 = markedly worsened to +2 = markedly improved (in analogy with the PAR Index).[19] Using this scale, it also cannot be assumed that the difference between e.g. –1 and 0 is the same as e.g. 0 and +1 or means the same for all raters.

Both the VAS scale and the 5-point scale are ordinal scales, rather than interval scales. However, by using mean scores from large panels, the scales can be treated as continuous, as long as the scores are normally distributed.[20]

8.3 Facial aesthetics and its relation to Angle Class and gender

Before treatment, no significant difference was found between the aesthetic scores for boys and girls. In the present study Class II division 2 patients had the highest VAS scores. However, the difference between the Angle Classes was only significant between Class II division 2 patients and Class III patients. In most investigations[21-26] adult as well as adolescent Class I patients are found to be the most attractive of all patients. It is not clear why Class I patients were not found to be the most attractive in our study. We also found that laymen gave the highest aesthetic scores for patients with horizontal sum values (overjet + ANB angle) higher than seen in most Class I patients. This is in agreement with Matoula and Pancherz[27] who also found that attractive females had larger ANB angles than unattractive females. Probably, orthodontists and laymen prefer more convex profiles nowadays than they did in the eighties and nineties.

After treatment, also no significant difference was found between the scores on the 5-point scale for boys and girls. Improvement as a result of orthodontic treatment was seen in all but Class III patients. This means that orthodontists should be cautious with expectations of aesthetic improvement in Class III patients, and inform these patients that, if facial aesthetics is their major concern, a combined orthodontic-orthognathic approach might be a better alternative than orthodontic treatment alone.

It can be concluded from the present investigation that Angle Class has an influence on change in facial attractiveness before and after treatment, but gender has not. Except for Class III patients, the expectations of parents of patients that their child will become more attractive after orthodontic treatment can be fulfilled to a certain degree.

8.4 Facial aesthetics and its relation to facial features

The age of the subjects ranged from 10 to 16 years. This means from pre-puberty to post puberty for most of the girls. Since puberty in boys occurs later than in girls, boys and girls might be at different stages of facial development. This might be a confounding variable in the results, but Halazonetis[28] reported that only subtle differences in profile shape between both genders were found in the age range from 7 to 17 years.

The ultimate goal of this investigation was to find variables for the development of an “Index of facial aesthetics” for the objective evaluation of facial aesthetics in adolescents. Different regression models were tested, but it was not possible to find a significant set of variables, that could explain its influence on facial aesthetics in adolescents. Therefore, none of these models can be used in the prediction of facial aesthetic scores, as given by laymen. However, some interesting components, dealing with facial aesthetics in adolescents became apparent from this thesis. The AC/IOTN, the horizontal sum (the combination of overjet and ANB angle) and Angle Class are important indicators. Four golden proportions, two ‘ideal’ proportions and three ‘ideal’ angles are also related to facial aesthetics in adolescents. Probably, further investigation on the combined effect of these factors may have potential for the development of an Index of facial aesthetics in adolescents.

It can be concluded from this study that overall facial aesthetics in adolescents does not depend on any single facial feature, but that it is related to many facial features. Probably, the evaluation of facial aesthetics is too complex to be explained by separate facial features or their combination. Probably, a more holistic approach to determine facial

aesthetics is more promising. Somehow, people are capable to decide in less than one second how attractive a face is,[29] and the use of a simple VAS with reference photographs, as has been used in this thesis, may be a good alternative to the reductionistic approach used so far. However, in order to make this measuring system generally applicable, it should be tested and validated in different countries.

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Chapter 9

Summary

Summary

In **chapter 1** the topic of facial aesthetics is introduced. Although facial beauty might be subjective and "in the eyes of the beholder", people agree on who is beautiful and who is not. Being beautiful is an advantage in real-live situations and is found to be as important for children and adults and for males as for females. Attractive individuals are not only judged and treated more positively, they also behave differently than unattractive ones. In this chapter subjects, panels, and measurement technique, used in the present study are described. Facial features, as objective parameters (overjet, ANB angle, Sn-GoGn angle, AC/IOTN), Angle Class, 'golden' ratios and 'ideal' proportions and angles and their relation to facial aesthetics in adolescents are introduced. The aims of this investigation and an overview of the study are presented.

In **chapter 2** a new measuring system to judge facial aesthetics in young Caucasians is presented. The system uses sets of three photographs (one frontal, one three-quarter smiling, and one lateral) as a stimulus. Scores are performed on a visual analogue scale (VAS) with separate sets of reference photographs for girls and boys. The choice of the reference sets was based on a panel evaluation of facial aesthetics of 40 boys and 40 girls. A male and a female set of photographs with an average aesthetic score close to the median VAS score were selected. Reproducibility of the new measuring system was tested on a series of photographic sets of 64 patients, using a panel of 78 adult laymen and 89 professionals. The panel members assessed these sets of photographs on a VAS, in relation to the reference sets. The system was shown to be reproducible. Although the intra-observer reproducibility was low, the reliability coefficient was excellent (Cronbach's alpha $\geq$ 0.98). Validity was tested by comparing the scores on the new scale with those of the three-quarter smiling photographic views on an earlier published scale by Peerlings. The correlation between the ratings on the new measuring system and the earlier published scale was 0.82 for the laymen and 0.77 for the professionals. The new system is simple and flexible in its use, and reproducible and valid for assessing facial aesthetics in young

Caucasians. The system can be used in further investigations on the evaluation of facial aesthetics.

The objective of the study described in **chapter 3** was to evaluate the influence of professional background, age, gender, and geographical region of panel members on their evaluation of the facial aesthetics of adolescents, and to assess the optimal panel size for epidemiological studies on facial aesthetics. A panel of 76 adult laymen from two different regions (Belgium and The Netherlands) and a panel of 89 orthodontists, from the same two regions, evaluated photographic sets of 64 adolescents (32 boys, 32 girls) on a VAS in relation to a reference set of photographs. The effects of the characteristics of the panel members on the VAS scores for boys and girls separately, as well as their interactions, were evaluated by multilevel models. These multilevel models revealed that laymen rated adolescents as more attractive than orthodontists. This finding was significant for all laymen, except for older males, and Belgian laymen, when rating girls. Older panel members rated boys significantly more attractive than younger panel members. Males rated adolescents more attractive than females. The latter was significant for all male subgroups, except for the lay male subgroup. There were regional differences. Based on the intraclass correlation coefficient, a panel of seven randomly selected laymen and/or orthodontists is sufficient to obtain reliable results in the aesthetic evaluation of adolescent faces, using photographs and a VAS.

The aim of the study described in **chapter 4** was to evaluate the influence of characteristics of panel members, the effects of gender and Angle Class of adolescent patients on their change in facial aesthetics following orthodontic treatment, and to assess the optimal panel size for epidemiological studies on change in facial aesthetics after orthodontic treatment. A panel of 74 adult laymen and a panel of 87 orthodontists evaluated post-treatment photographic sets of 64 adolescent orthodontic patients in relation to the pre-treatment sets of the same patient on a 5-point scale. The main effects of professional background, age, gender, and geographical region of the panel members on the aesthetic scores, as

well as their first order interactions were evaluated by multilevel models. Professional background, age, gender, and geographical region of panel members had an influence on the evaluation of the change of facial aesthetics following orthodontic treatment. The effect of gender and Angle Class of the patients on the scores was evaluated by two-way ANOVA. There was no difference in the mean scores for boys and girls. Improvement of facial aesthetics by orthodontic treatment was significant for Class I, Class II division 1, and Class II division 2 patients, but not for Class III patients. Based on the intraclass correlation coefficient (ICC), a panel of nine randomly selected orthodontists, a panel of 14 randomly selected laymen, or a mixed panel of 13 individuals is sufficient to obtain reliable results in the aesthetic evaluation of adolescent faces, using photographs and a 5-point scale.

The objective of the study described in **chapter 5** was to examine the contribution of objective measures, representing anterior-posterior and vertical characteristics, dental aesthetics, or their combination that are used in daily orthodontic practice in the assessment of facial aesthetics. A panel of 78 laymen evaluated facial aesthetics of 32 boys and 32 girls, stratified over the four Angle Classes, on a VAS. The relation between the objective parameters and facial aesthetics was evaluated by backward multiple regression analysis. Dental aesthetics as expressed by the Aesthetic Component of the Index of Orthodontic Treatment Need (AC/IOTN) appeared to be the most important indicator for facial aesthetics. A new parameter, the “horizontal sum” was found to be a reliable variable for the anterior-posterior characteristics of the patient. Addition of this newly defined parameter to the AC/IOTN improves the prognostic value from 25% to 31%.

In **chapter 6** a study is described in which the putative relation between facial aesthetics and golden proportions in Caucasian adolescents is tested. Adult laymen (N=76) evaluated sets of photographs of 64 adolescents on a VAS. The facial aesthetic value of each patient was calculated as a mean VAS score. Three observers recorded the position of 13 landmarks included in the putative golden proportions.

Nineteen proportions, based on the golden proportions as defined by Ricketts, were determined, and the deviation of each proportion from the golden target (1.618) was calculated. The deviation was related to the VAS scores. Only four out of the 19 Pearson correlations between the deviation of the golden target and the VAS scores pointed into the proper direction, and were significant. Together, these variables explain only 16 % of the variance.

Chapter 7 reports on the study in which the hypothesis is tested that facial attractiveness in adolescents is related to ideal angles and ratios as indicated in the literature. Adult lay people (N=76) evaluated sets of photographs of 64 adolescents on a VAS. The facial esthetic value of each individual was calculated as a mean VAS score. Three observers recorded the position of 61 landmarks. Out of these, 45 landmarks with an acceptable reproducibility were found. Twenty-seven ideal ratios on frontal, and twenty-six ideal angles on lateral photographs, dealing with the accepted landmarks were found in the literature. These ratios and angles were calculated on the individual photographs as well as their deviation from the ideal target from literature. This deviation was related to the VAS scores. Two ratios and three angles had a significant negative correlation with the VAS scores, indicating that beautiful faces showed less deviation from the ideal target than less beautiful faces. Together, these variables explain 28.7% of the variance.

In **chapter 8** a general discussion is given on the study as a whole and suggestions are made for further research.

Chapter 10

Samenvatting

Samenvatting

Hoofdstuk 1 is een inleiding op het onderwerp gelaatsesthetiek. Hoewel esthetiek van het aangezicht verondersteld wordt een subjectief gegeven te zijn ("in the eyes of the beholder"), toch is iedereen het eens over wie mooi is en wie niet. Mooi zijn is een voordeel in onze maatschappij. Kinderen en volwassenen, mannen en vrouwen vinden het belangrijk om mooi te zijn. Mooie mensen worden niet alleen beter beoordeeld door hun omgeving, ze gedragen zich ook anders dan minder mooie mensen. In dit hoofdstuk worden de onderzoeksgroep, de beoordelaars en de meetmethoden, die gebruikt zijn in het onderzoek, besproken. Een aantal objectieve parameters (zoals overjet, ANB hoek, Sn-GoGn hoek, AC/IOTN), Angle Klasse, 'gouden' verhoudingen en 'ideale' verhoudingen en hoeken die van belang kunnen zijn de gelaatsesthetiek bij adolescenten worden geïntroduceerd. In dit hoofdstuk worden tevens de doelstellingen van dit onderzoek alsmede een overzicht van het onderzoek gepresenteerd.

In **hoofdstuk 2** wordt een nieuwe meetmethode beschreven om gelaatsesthetiek te meten bij adolescenten. Deze methode maakt gebruik van een set van gelaatsfoto's (een frontale, een ¾ lachende en een laterale). Deze gelaatsfoto's worden gescoord op een visual analogue scale (VAS) met een verschillende referentieset voor jongens en meisjes. De keuze van deze referentiesets was gebaseerd op een panelevaluatie van gelaatsesthetiek van 40 jongens en 40 meisjes. Een set gelaatsfoto's van een jongen en van een meisje, met een gemiddelde score dicht bij de mediane VAS waarde, werden hiervoor geselecteerd. De reproduceerbaarheid van het nieuwe meetsysteem werd getest op de beoordeling van een reeks sets van gelaatsfoto's van 64 patiënten door een panel van 78 volwassen leken en een panel van 89 orthodontisten. De panelleden beoordeelden deze sets van gelaatsfoto's op een VAS, in relatie met de referentiesets. De reproduceerbaarheid van het meetsysteem was goed. Hoewel de intra-observer reliability vrij laag was, was de reliability coëfficiënt zeer hoog (Cronbach's alpha ³ 0.98). De validiteit van het nieuwe meetsysteem werd getest door een vergelijking

van de scores op de nieuwe schaal met de scores van de ¾ lachende foto's op een eerder door Peerlings gepubliceerde schaal. De correlatie tussen de scores op beide schalen was 0.82 voor de leken en 0.77 voor de orthodontisten. Het nieuwe meetsysteem is eenvoudig en gemakkelijk te gebruiken en is reproduceerbaar en valide voor de beoordeling van gelaatsesthetiek bij Caucasische jongeren. Het meetsysteem kan gebruikt worden in verder onderzoek naar gelaatsesthetiek.

Het doel van het in **hoofdstuk 3** beschreven onderzoek was de invloed na te gaan van professionele achtergrond, leeftijd, geslacht en woonplaats van panelleden op hun evaluatie van gelaatsesthetiek bij adolescenten, alsook het bepalen van de optimale grootte van een panel om gelaatsesthetiek te meten in het kader van epidemiologische studies. Een panel van 76 leken uit België en Nederland en een panel van 89 orthodontisten uit dezelfde landen beoordeelden sets van gelaatsfoto's van 64 patiënten (32 jongens en 32 meisjes) op een VAS in relatie met sets van referentiefoto's. Het effect van de karakteristieken van het panel op hun VAS scores zowel voor jongens als voor meisjes, alsook hun interacties werden geëvalueerd met multilevel technieken. Het gebruikte multilevel model toonde aan dat de adolescenten mooier werden bevonden door de leken dan door de orthodontisten. Deze bevinding was significant voor alle leken, behalve voor oudere mannen en Belgische leken in de beoordeling van de meisjes. De oudere panelleden vonden de jongens mooier dan de jongere leken. De mannen vonden de adolescenten mooier dan de vrouwen. Deze bevinding was significant voor alle mannen, behalve voor de mannen uit het lekenpanel. Bovendien waren er ook regionale verschillen tussen de verschillende panels. Gebaseerd op de intraclass correlation coëfficiënt kan men stellen dat een panel van zeven willekeurig gekozen panelleden, leken en/of orthodontisten, voldoende is om een reproduceerbare beoordeling te geven over gelaatsesthetiek bij adolescenten als foto's en een VAS gebruikt worden.

Het doel van het in **hoofdstuk 4** beschreven onderzoek was de invloed na te gaan van professionele achtergrond, leeftijd, geslacht en woonplaats van panelleden op hun evaluatie van gelaatsesthetiek bij

adolescenten na orthodontische behandeling, alsook het bepalen van de optimale grootte van een panel om verandering van gelaatsesthetiek na orthodontische behandeling te meten in het kader van epidemiologische studies hieromtrent. Een panel van 74 volwassen leken en een panel van 87 orthodontisten evalueerden de sets van gelaatsfoto's na orthodontische behandeling van 64 adolescente patiënten in relatie met de gelaatsfoto's voor de orthodontische behandeling van dezelfde patiënt op een 5-punt-schaal. De hoofdeffecten van professionele achtergrond, leeftijd, geslacht en woonplaats, zowel als hun first order interacties werden geëvalueerd met behulp van multilevel technieken. Professionele achtergrond, leeftijd, geslacht en woonplaats van de panelleden hebben een invloed op de evaluatie van verandering van gelaatsesthetiek na orthodontische behandeling. Het effect van geslacht en Angle Klasse van de adolescente patiënten werd geëvalueerd met two-way ANOVA. Er werd geen verschil gevonden tussen de gemiddelde scores voor jongens en meisjes. Verbetering van gelaatsesthetiek na orthodontische behandeling was significant voor Klasse I, Klasse II,1 en Klasse II,2 patiënten, maar niet voor Klasse III patiënten. Gebaseerd op de intraclass correlation coëfficiënt kan men stellen dat een panel van negen willekeurig gekozen orthodontisten, of een panel van 14 willekeurig gekozen leken, of een mixed panel van 13 leden voldoende is om een reproduceerbare beoordeling te geven over gelaatsesthetiek bij adolescenten bij het gebruik van foto's en een 5-punt-schaal.

Het doel van de studie in **hoofdstuk 5** beschreven studie was na te gaan of objectieve metingen die gebruikt worden in de dagelijkse orthodontische praktijk zoals voor-achterwaarste en verticale karakteristieken, dentale esthetiek of hun combinatie, een invloed hebben op de beoordeling van gelaatsesthetiek. Een panel van 78 volwassen leken evalueerde de gelaatsesthetiek van 32 jongens en 32 meisjes, evenredig verdeeld over de vier Angle Klassen, op een VAS. De relatie tussen de objectieve parameters en gelaatsesthetiek werd geëvalueerd door middel van backward meervoudige regressie analyse. De esthetiek van de tanden, zoals geëvalueerd met de AC/IOTN was de belangrijkste factor die meespeelde om gelaatsesthetiek te beoordelen. Een nieuwe

parameter, de “horizontal sum” bleek een goede parameter te zijn om de voor-achterwaarste karakteristiek van een patiënt te bepalen. Toevoeging van deze nieuwe parameter aan de AC/IOTN verhoogt de verklaarde variantie van 25% tot 31%.

In **hoofdstuk 6** wordt een studie beschreven naar het mogelijke verband tussen gelaatsesthetiek en “gouden verhoudingen” bij Caucasische adolescenten. Volwassen leken (N=76) evalueerden sets van gelaatsfoto’s van 64 adolescenten op een VAS. De gemiddelde VAS score was bepalend voor de gelaatsesthetiek van de patiënt. Negentien verhoudingen, gebaseerd op de gouden verhoudingen zoals beschreven door Ricketts, werden onderzocht en de afwijking van elk van deze verhoudingen met de gulden snede (1.618) werd berekend. Drie onafhankelijke onderzoekers duidden op de gelaatsfoto’s de positie aan van 13 punten betrokken in de gouden verhoudingen. De afwijking met de gulden snede werd gerelateerd aan de VAS scores. Slechts vier van de 19 Pearson correlaties tussen de afwijking van de gulden snede en de VAS scores hadden een significante relatie met gelaatsesthetiek. De verklaarde variantie van deze vier variabelen is slechts 16%.

Hoofdstuk 7 beschrijft de studie waarin de hypothese wordt onderzocht dat gelaatsesthetiek bij adolescenten gerelateerd is aan ‘ideale’ verhoudingen en hoeken. Volwassen leken (N=76) evalueerden sets van gelaatsfoto’s van 64 adolescenten op een VAS. De gelaatsesthetiek van elk van de adolescenten werd gedefinieerd als de gemiddelde VAS score, gegeven door deze leken. Drie onafhankelijke onderzoekers gaven op de gelaatsfoto’s de positie aan van 61 punten. De reproduceerbaarheid van deze punten werd getest. Slechts 45 punten hadden een acceptabele reproduceerbaarheid. In de literatuur werden op frontale foto’s zevenentwintig ‘ideale’ verhoudingen en op laterale foto’s zesentwintig ‘ideale’ hoeken gevonden, die een verband hebben met gelaatsesthetiek en waarin deze reproduceerbare punten betrokken zijn. Deze verhoudingen en hoeken werden berekend per set van foto’s alsook hun individuele afwijking van het gestelde ideaal, zoals beschreven in de literatuur. Deze afwijking werd gerelateerd aan de VAS scores. Twee

verhoudingen en drie hoeken vertoonden een significante relatie met gelaatsesthetiek. Dit betekent dat mooie gezichten een kleinere afwijking hadden van deze ideale target dan minder mooie gezichten. De verklaarde variantie van deze variabelen is 28.7%.

In **hoofdstuk 8** wordt een algemene discussie gegeven over dit onderzoek en worden suggesties gegeven voor verder onderzoek.

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Over de auteur…

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Van 1981 tot 1983 was zij vrijwillig deeltijds medewerker bij de afdeling Orthodontie van de Universiteit Gent, België en van 1990 tot 1997 was ze deeltijds docent bij de afdeling Orthodontie van de Katholieke Universiteit Leuven, België.

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